सत्यमेव जयते

INDIAN AGRICULTURAL

RESEARCH INSTITUTE, NEW DELH

28641

I.A.R I.6.
GIP NLK—H-3 I.A.R.I.—10 5-55—15,000

INDIAN JOURNAL OF MALARIOLOGY.

Linlithgow Library.
Imperial Agricultural Research Institute
New Delhi.

29641
IARI

सत्यमेव जयते

All rights reserved

INDIAN JOURNAL OF MALARIOLOGY.

PUBLISHED UNDER THE AUTHORITY OF

THE INDIAN RESEARCH FUND ASSOCIATION

Editor :—Lieut.-Colonel JASWANT SINGH, M.B., Ch.B., D.P.H., D.T.M. & H.

Vol. II, 1948.

PUBLISHED FOR

THE INDIAN RESEARCH FUND ASSOCIATION

BY

THACKER'S PRESS & DIRECTORIES, LTD., CALCUTTA

Price per volume: Twelve rupees (or seventeen shillings six pence) including postage.

Single copies: Five rupees (or seven shillings three pence) excluding postage.

Printed by M. V. GOUGH-GOVIA at
THACKER'S PRESS & DIRECTORIES, LTD.,
6, Bentinck Street, CALCUTTA.

TABLE OF CONTENTS.

Vol. II.

Nos. 1 and 2 (March/June 1948).

No. 3 (September 1948).

No. 4 (December 1948).

Vol. II, Nos. 1 and 2. *March/June 1948.*

INDIAN JOURNAL OF MALARIOLOGY.

PUBLISHED UNDER THE AUTHORITY OF

THE INDIAN RESEARCH FUND ASSOCIATION.

EDITOR :—LIEUT.-COLONEL JASWANT SINGH, M.B., Ch.B., D.P.H., D.T.M. & H.,

Director, Malaria Institute of India.

PUBLISHED FOR

THE INDIAN RESEARCH FUND ASSOCIATION

BY

THACKER'S PRESS & DIRECTORIES, LTD., CALCUTTA.

experience has proved that

TRADE MARK

'QUINACRINE'

BRAND

mepacrine hydrochloride

is effective in the treatment and suppression of malaria

Adequate stocks are available

Supplies: **tablets in containers of 15, and 100 and 500.**
'QUINACRINE SOLUBLE' brand mepacrine methanesulphonate ampoules containing the equivalent of 0.10 Gm. and of 0.30 Gm. in boxes of 6 and 25

manufactured by

MAY & BAKER LTD.

Distributed by MAY & BAKER (INDIA) LIMITED

Indian Journal of Malariology, 2, 1 and 2, March/June 1948.

CONTENTS.

(All rights reserved.)

THE AMERICAN JOURNAL OF TROPICAL MEDICINE

Official organ of the American Society of Tropical Medicine.

Published bi-monthly, one volume each year. Established 1921.

Subscription price $5.50 per volume including postage, or Rs. 19-8.

The journal is read in the Union and in nearly 50 countries all over the world as a current record of the advances in tropical medicine. In addition to clinical, practical, and public health studies, material is included on chemistry, pathology, bacteriology, protozoology, helminthology, entomology, etc.

This policy of inclusiveness is restricted by the fact that the treatment of all subjects is strictly from the view-point of tropical medicine.

Orders can be placed directly with :

THE WILLIAMS & WILKINS CO.

Mt. Royal and Guilford Avenues, Baltimore, Md., U.S.A.

LINGNAN SCIENCE JOURNAL

This quarterly journal, published by the Lingnan University, offers original articles on biology, physical sciences, agriculture, public health, and related fields, in China. It is printed in English and other languages and each article has a Chinese abstract. The journal also includes a Book Review section and an extensive Abstracts section, in which an attempt is made to review the current periodical literature dealing with science in China. News is given of new publications, scientific expeditions and conferences under the heading of General Notes.

The Lingnan Science Journal prints over 700 pages a year and 16 annual volumes have been published. It may be secured through exchange or by subscription of $5.00 Chinese national currency, foreign U. S. $3.00. A sample copy will be sent on request. Manuscripts, subscriptions and inquiries should be addressed :

LINGNAN SCIENCE JOURNAL

Room 302, Science Hall

Lingnan University

Canton, China

Indian Journal of Malariology, **2**, 1 and 2, June, 1948.

CHLOROQUINE (SN 7618) IN MALARIA.*

BY

R. N. CHAUDHURI, M.B., M.R.C.P., T.D.D.,

M. N. RAI CHAUDHURI, M.B.,

AND

N. K. CHAKRAVARTY, M.B.

(*Department of Tropical Medicine, School of Tropical Medicine, Calcutta.*)

[February 6, 1948.]

CHLOROQUINE or resochin or aralen, also known as SN 7618, is 7-chloro-4 (4-diethylamino-1-methylbutylamino) quinoline. It was first synthesized in Germany and slightly modified later under the name of Sontochin. The allied forces when they occupied Tunis in 1943 took charge of this chemical and for three years the U. S. Board for the Co-ordination of Malarial Studies examined its effects on malaria and published a report in the *Journal of the American Medical Association* in 1946 (Vol. 130, p. 1069). While its properties are somewhat similar to those of mepacrine, it possesses about three times the activity of mepacrine and is highly effective against the asexual forms of malaria parasites of all species. It is said to effect a radical cure in *falciparum*, but though it is effective in terminating an acute attack of *vivax* malaria, it does not prevent the occurrence of relapses in all cases. This drug is reported to have no action on the exo-erythrocytic forms of parasites but a single weekly dose of 0·25 gm. suppresses malarial attacks in almost all cases. Its additional advantage lies in the fact that it does not discolour the skin. The present report deals with the result of clinical trials on patients suffering from Indian strains of malaria parasites with a supply of this drug (SN 7618-5) received in 1947.

MATERIAL.

In this series 50 patients with active malarial infection were carefully selected and treated with this drug in the Carmichael Hospital for Tropical Diseases,

* This investigation was carried out under the Indian Research Fund Association.

Calcutta. They included 18 *falciparum*, 27 *vivax*, 4 mixed (*falciparum* and *vivax*) and one *malariæ* infections. They were studied particularly with the object of determining the time taken in controlling fever, the time for the asexual parasites to disappear from the peripheral blood and side effects if any. Four-hourly temperature charts were maintained and thick blood films stained by Field or J. S. B. technique were examined twice daily until the blood became negative for asexual parasites and thereafter only once daily throughout the period during which the patients were kept under observation in the hospital.

DOSAGE.

The drug was administered in tablet form, each tablet weighing just over 0·4 gm. and containing 0·25 gm. of the base. The two regimes of treatment 'A' and 'B' were tried in 42 and 8 cases respectively.

Forty-six patients were above 12 years and the remaining 4 under 12 years.

Regime 'A'.—Two tablets for the first dose followed by one tablet after 6 hours and then one tablet on each of the two following days—comprising a total of 5 tablets.

Regime 'B'.—A single dose of 6 tablets.

The scheme of dosage in different age groups was as follows :—

TABLE I.

		Above 12 years.	6 to 12 years.	Below 6 years.
Regime 'A'	1st day ...	2 tablets *stat* and 1 six hours later.	1 tablet *stat* and 1 six hours later.	½ tablet *stat* and ½ six hours later.
	2nd day ...	1 tablet	½ tablet	½ tablet.
	3rd day	1 tablet	½ tablet	½ tablet.
	TOTAL ...	5 tablets	3 tablets	2 tablets.
Regime 'B' ...	Single dose	6 tablets	4 tablets	2 tablets.

The distribution of patients according to race, sex and age is shown in Table II.

TABLE II.

Infection.	Total number.	RACE. Bengali.	RACE. Other Indians.	RACE. Non-Indians.	SEX. Males.	SEX. Females.	AGE IN YEARS. Up to 12.	AGE IN YEARS. 13 to 20.	AGE IN YEARS. Above 20.
Falciparum	18	6	11	1	15	3	2	4	11
Vivax	27	14	13	0	26	1	1	6	21
Mixed (*falciparum* and *vivax*) ...	4	2	2	0	4	0	1	0	3
Malariæ	1	1	0	0	1	0	0	0	1
TOTAL ...	50	23	26	1	46	4	4	10	36

RESULTS OF TREATMENT.

All cases irrespective of the dosage and the nature of infection became afebrile and asexual parasites disappeared rapidly. The immediate effects on the temperature and the parasites are shown in Table III :—

TABLE III.

Regime.	Serial number.	Infection.	Duration of fever in hours.	Asexual parasites seen in hours.	GAMETOCYTES FIRST SEEN Before treatment.	GAMETOCYTES FIRST SEEN During treatment.	Gametocytes seen in days.	Duration of stay in hospital, in days.
A	1	F, V	21	60	+	...	6	13
	2	F	16	36	+	...	17	23
	3	F	52	24	...	+	2	15
	4	F	12	24	...	+	3	9
	5	V	30	72	+	...	5	15
	6	F	17	72	+	...	10	10

F = *falciparum*. V = *vivax*.

TABLE III—*contd.*

Regime.	Serial number.	Infection.	Duration of fever in hours.	Asexual parasites seen in hours.	Gametocytes first seen: Before treatment.	Gametocytes first seen: During treatment.	Gametocytes seen in days.	Duration of stay in hospital, in days.
A	7	F, V	19	25	+	...	2	24
	8	F	15	25	...	...	0	9
	9	F	16	24	...	...	0	5
	10	V	9	48	+	...	3	12
	11	F	9	24	+	...	7	15
	12	V	0	20	+	...	3	28
	13	V	38	30	+	...	3	26
	14	V	24	40	...	...	0	10
	15	V	24	24	...	...	0	10
	16	F	24	40	...	...	0	10
	17	V	35	30	+	...	2	14
	18	V	35	30	+	...	2	21
	19	V	30	30	+	...	2	20
	20	V	0	20	+	...	3	33
	21	F	56	56	...	...	0	5
	22	V	28	30	+	...	4	24
	23	V	44	40	...	...	0	25
	24	F, V	32	30	...	...	5	13
	25	F	10	24	+	...	2	10
	26	V	48	68	+	...	5	8
	27	V	49	55	+	...	3	18
	28	F	34	42	...	...	0	19
	29	V	30	24	+	...	2	6

F = *falciparum*. V = *vivax*.

TABLE III—*concld.*

Regime.	Serial number.	Infection.	Duration of fever in hours.	Asexual parasites seen in hours.	Gametocytes first seen: Before treatment.	Gametocytes first seen: During treatment.	Gametocytes seen in days.	Duration of stay in hospital, in days.
A	30	F, V	29	24	+	...	2	13
A	31	F	40	60	+	...	13	15
A	32	F	17	40	+	...	22	22
A	33	F	16	24	...	...	0	13
A	34	V	36	36	+	...	3	8
A	35	V	24	24	...	+	1	49
A	36	V	12	24	+	...	3	7
A	37	M	30	24	+	...	10	26
A	38	F	17	24	...	...	0	31
A	39	V	36	36	...	...	0	10
A	40	V	12	48	+	...	5	15
A	41	V	24	24	+	...	1	10
A	42	F	12	20	...	...	0	38
B	1	V	30	24	...	...	0	10
B	2	V	30	24	+	...	3	30
B	3	F	36	40	+	...	5	21
B	4	V	20	20	+	...	1	8
B	5	V	24	24	...	...	0	8
B	6	V	36	24	...	...	0	10
B	7	V	8	24	+	...	3	8
B	8	F	15	24	+	...	11	11

F = *falciparum*. V = *vivax*. M = *malariæ*.

The effect of treatment has been (1) to bring down the temperature to normal in an average period of 26·8 hours with regime 'A' and 24·9 hours with regime 'B' and (2) to cause disappearance of asexual parasites in 35 hours with regime 'A' and 25·5 hours with regime 'B'. These results prove the effectiveness of this drug in terminating an attack in a reasonably short time. The clinical response is better illustrated in Charts 1 to 5.

CHART 1.

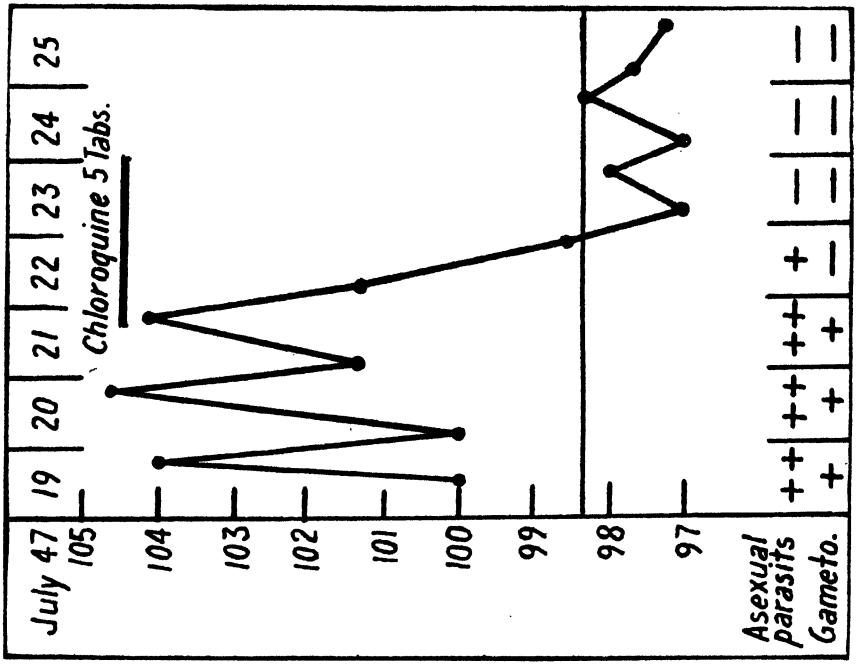


CHART 1.—*P. vivax* malaria treated with regime 'A'.

CHART 2.

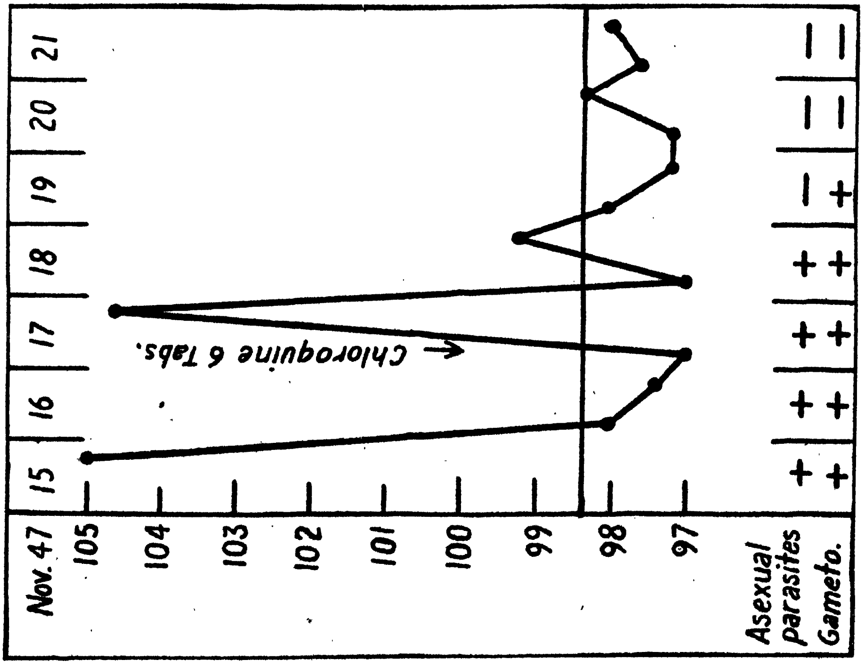


CHART 2.—*P. vivax* malaria treated with regime 'B'.

CHART 3.

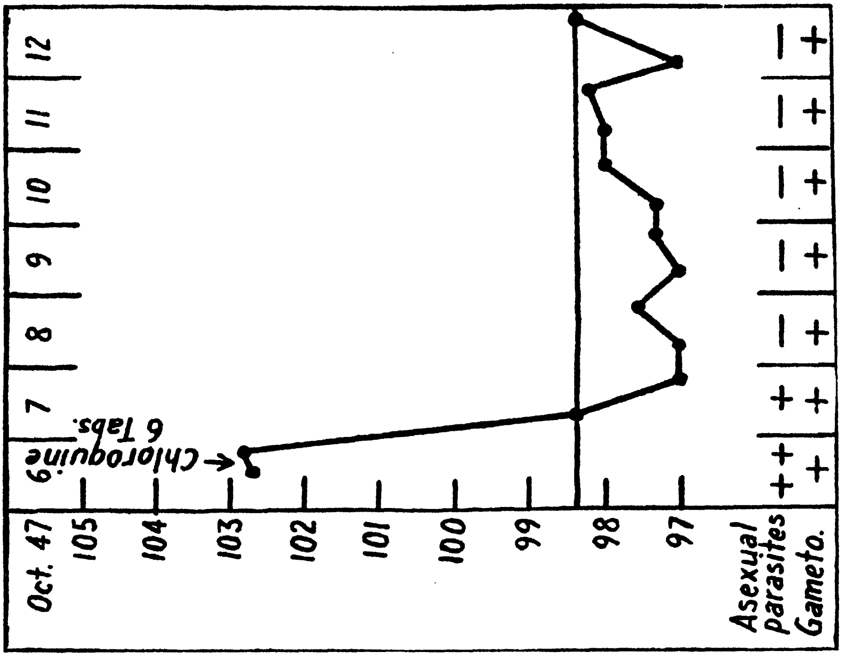


CHART 3.—*P. falciparum* malaria treated with regime 'B'.

CHART 4.

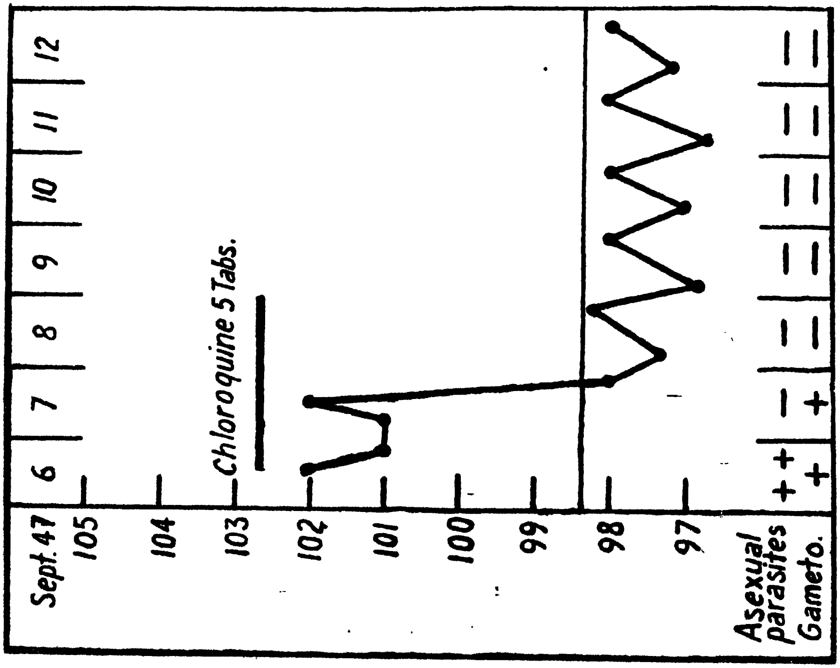


CHART 4.—A case of mixed *P. falciparum* and *vivax* infection treated with regime 'A'.

CHART 5.

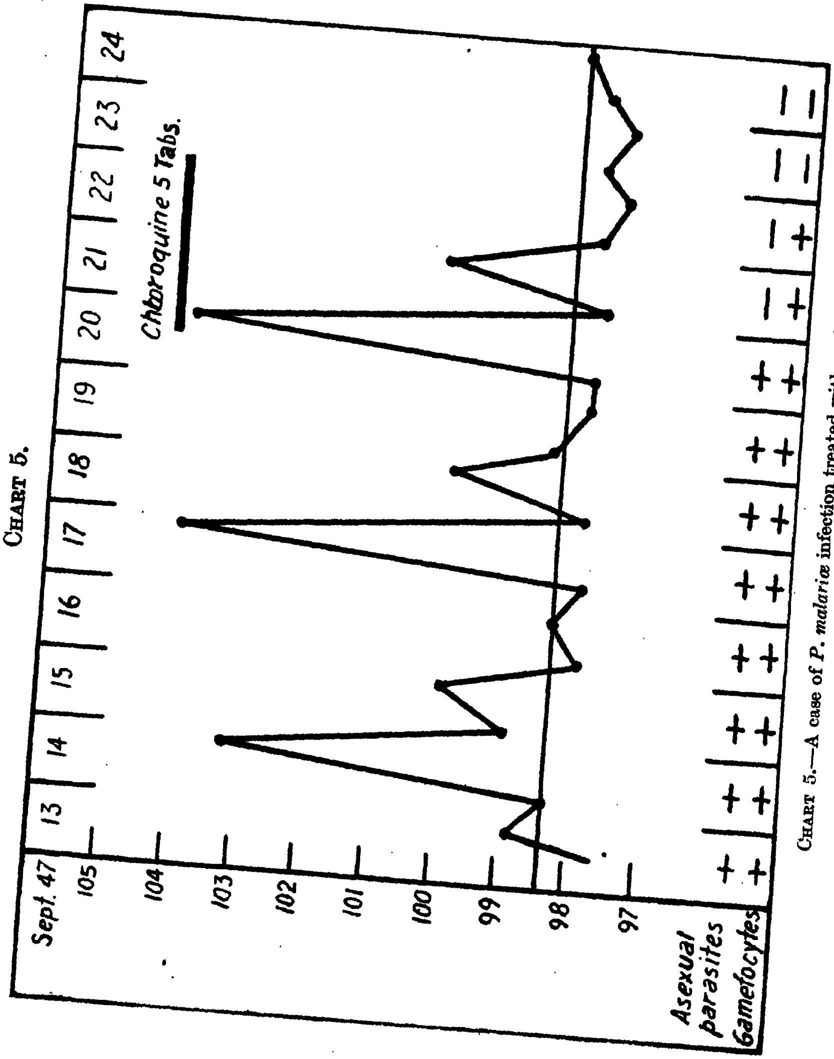


CHART 5.—A case of *P. malariæ* infection treated with regime 'A'.

The day-to-day effects of chloroquine on temperature and asexual parasites are shown in Table IV.

TABLE IV.

Infection.	Total number of cases.	Number of cases free from fever in (days).				Asexual parasites in blood disappeared in (days).			
		1	2	3	4	1	2	3	4
Falciparum	18	13	3	2	0	7	5	5	1
Vivax	27	10	15	0	0	9	14	4	0
Falciparum and *vivax* ...	4	3	1	0	0	3	1	0	0
Malariæ	1	0	1	0	0	1	0	0	0
TOTAL ...	50	26	20	2	0	20	20	9	1
PER CENT ...	100	52	40	4	0	40	40	18	2

Two *vivax* cases which had no fever on the day the treatment was started did not subsequently develop paroxysm. It is evident from the table that the temperature did not persist in the majority of cases beyond the second day of treatment. Only 2 patients (4 per cent) had fever on the third day. Peripheral blood became negative within 2 days in 80 per cent of the cases, and on the third day the asexual parasites were seen in 9 patients (18 per cent) and on the fourth day in only one patient (2 per cent).

Taking *P. falciparum* and *P. vivax* cases separately it will be seen from Tables IV and V and Figures 1 and 2 that chloroquine, judging from immediate effect, appears to be more active in *vivax* than in *falciparum* infection. The number of cases studied however in each series has not been sufficiently large to come to a statistically significant conclusion on this point.

TABLE V.

	Number of cases.	Average duration of fever.	Number of cases where fever subsided in first 2 days.	Average duration of asexual parasites.	Number of cases cleared of parasites in first 2 days.
P. falciparum ...	18	23 hours	16 (89 per cent)	34·6 hours	12 (66·7 per cent).
P. vivax ...	27	25 hours	27 (100 per cent)	33·2 hours	23 (85·1 per cent).

FIGURE 1.

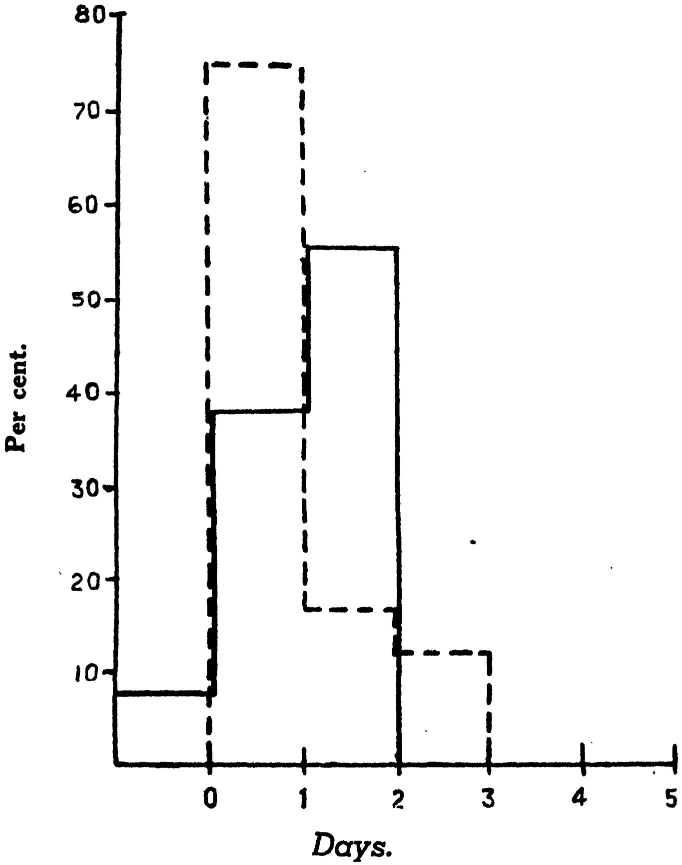


FIGURE 1.—The effect of chloroquine on the temperature in *vivax* and *falciparum* malaria represented by the continuous and the dotted line respectively. The results are expressed as percentage of the total in each group. The abscissa indicates the last day of fever after the administration of the drug. The column '0' represents the cases where no paroxysm occurred following the administration of the drug on the apyrexial day.

FIGURE 2.

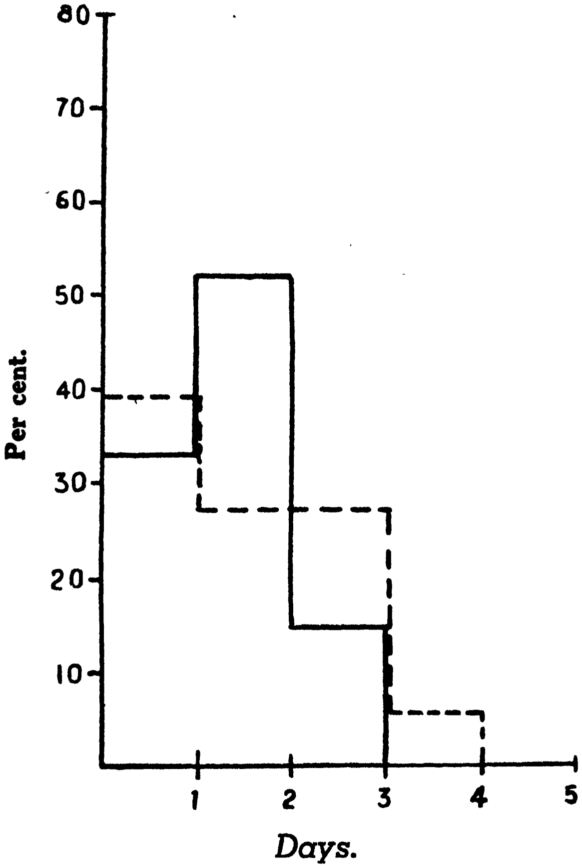


FIGURE 2.—The effect of chloroquine on the asexual parasites of *P. vivax* and *P. falciparum* represented by the continuous and the dotted line respectively. The results are expressed as percentage of the total in each group. The abscissa indicates the day after the administration of the drug on which the asexual parasites were last seen in the peripheral blood.

RELAPSES.

All the 50 patients were under observation in the hospital for 5 to 49 days (up to 10 days, 20 cases; 11 to 20 days, 15 cases; 21 to 30 days, 11 cases; and over 30 days, 4 cases) during which time none of them had a relapse. After discharge 20 patients could be observed regularly for varying periods—6 cases

for one to two months, 4 cases for two to three months, 4 cases for three to four months and 6 cases for 5 to 7 months. Two of these patients with *falciparum* infection relapsed after 30 and 45 days respectively after discharge from the hospital and two with *vivax* infection after 45 and 210 days. Re-infection of course could not be definitely excluded.

GAMETOCYTES.

Gametocytes were present in the peripheral blood in 33 patients before the drug was given and persisted for a variable period (up to 22 days in this series) showing that they are unaffected by this drug. Out of the remaining 17 patients, gametocytes did not appear in 14 cases but were seen temporarily for the first time during treatment in 3 cases under regime 'A' but they could not be seen in them after the course had been completed.

TOXIC ACTION.

Some untoward effects of the drug were observed in five patients. They complained of one or more of the following symptoms: insomnia (4 cases), gastro-intestinal irritation (1 case), pruritus especially of the hands and feet (3 cases), and pain in the lower abdomen, genitals and thighs (1 case). These unpleasant side effects of chloroquine were observed with both regimes of treatment but they disappeared within two days.

SUMMARY AND CONCLUSION.

A report on clinical trials with chloroquine (SN 7618) on 50 malaria cases is given. The therapeutic course is short, it is fairly well tolerated and brings the temperature to normal in an average period of 26·8 hours with regime 'A' and in 24·9 hours with regime 'B'. It clears the peripheral blood of asexual parasites in an average period of 35 hours with regime 'A' and 25·5 hours with regime 'B'. The number of patients treated with regime 'B' is however too small to be compared with regime 'A'. Taking both the regimes together the temperature became normal in an average period of 25·5 hours and asexual parasites disappeared from the blood in 33·3 hours. Although the series is rather small, these results have shown that the drug is effective in terminating an attack in a shorter time as compared with quinine, mepacrine or paludrine. Twenty per cent of the cases have so far relapsed. It has been reported that a single weekly dose of 0·25 gm. of chloroquine is sufficient to suppress malaria. If this is confirmed this drug will prove more effective than mepacrine or paludrine, but from the practical point of view, we must consider that chloroquine is more expensive and has a toxic action which, though mild and temporary, occurred in 10 per cent of the cases. The gametocytes were apparently unaffected, but in those cases in which they were absent when the treatment was started, they frequently failed to appear subsequently.

ACKNOWLEDGMENT.

The authors wish to record their grateful thanks to Dr. H. Chakravarti and Mr. C. L. Mitter of this department for their valuable assistance in this investigation.

Indian Journal of Malariology, **2**, 1 and 2, June, 1948.

MALARIA TRANSMISSION IN THE LIGHT OF MODERN EVOLUTIONARY THEORY APPLIED TO MALARIA-CARRYING MOSQUITOES.

BY

R. SENIOR WHITE, F.R.S.E.

[February 20, 1948.]

IN 1942 Dr. Julian Huxley published his book '*Evolution—The Modern Synthesis*'. The book was not obtainable in India until 1944, since when the author has read and re-read this great work, making notes classified under various aspects as considered in the present paper,* in which it is proposed to discuss the various statements in their bearing upon mosquito biology. Many of the concepts discussed may be new to the younger generation of malaria workers whose education has been primarily medical and whose basic theoretical knowledge of mosquitoes and malaria has been gained in courses of limited duration in which only the essentials can be taught. Yet if further progress in malaria prevention and its extension by biological control methods, which alone are financially suited to vast rural areas, is to be achieved, it appears to be necessary that these concepts be understood. Through understanding there may in time arise the possibility of the control of mosquito-borne diseases by 'race-substitution', as an extension of the already known concept of 'species-substitution', first envisaged by Watson (1921), and subsequently practised in Malaya by Williamson (1935). The present author (Senior White, 1936) has also given instances of malaria control by species-substitution, with results which even suggested that the substituted *Culex fatigans* of his work was a race which did not attack man.

To malaria workers of many years standing, however widely read in the literature of malaria and its cognate sciences, Huxley's book is so packed with thought-provoking statements, with examples from many orders, zoological and botanical, quoted in their support that it is felt that too much attention can hardly be paid to it, and if this paper leads fellow workers to study it, and by cognate reading and by personal observation and experimentation to follow up some of the lines suggested, it will achieve its object. After thirty years devoted to mosquito biology and malaria the writer realizes more fully than ever the depths of our

---

* **Quotations, some of them paraphrased for brevity, from '*Evolution*' are printed in heavy type, with references to the page in brackets. They are not otherwise listed. References to other publications are given in the usual manner.**

ignorance and the fact that we only stand fifty years after Ross' discovery on the threshold of knowledge of the mosquito and of the diseases of which it is the carrier.

Of the two hundred or so species of anopheles now known from all over the world the number which have been intensively studied biologically are but few. As regards their capacity as vectors of malaria, nearly every anopheline species which has been tested for human malaria has been shown to carry experimentally (Barber, 1921), but the number which are major vectors in nature is not more than twenty-five per cent of the total (Hackett, 1937). This proves that there is something, other than constitutional discordance, as described below, between the insect and the protozoon that results in such a relatively small number being successful transmitters of sporozoites. This is not to say that all species of plasmodium require anopheline mosquitoes for their development. Of the numerous species of avian plasmodia few will develop in any species of this tribe, their natural vectors being various culicine genera, none of which, on the contrary, have been fully proved to carry any of the human species, though Williamson and Zain (1937) have educed evidence for this in *C. bitæniorhynchus*. Possibly, as in various species of Glossina, the digestion of anucleate and nucleate R.B.C. is concerned in the difference between the vectors.

Within a single species the researches of Huff (1931) have shown that the capacity for successful plasmodial development varies in individuals and is subject to Mendelian segregation. Development must therefore depend upon differences which under the conditions of Huff's work can only be those of tissue constitution and metabolism. Huff worked with *Culex pipiens* and *Plasmodium cathenerium*. Boyd and Russell (1943) in a preliminary paper have reported failure to confirm his results with *A. quadrimaculatus* and *P. vivax*. In a species showing such important differences in vectorial status as does *A. culicifacies* (Senior White, 1940) this line would well repay following, *pari passu* with the search for crypto-races only distinguishable by chromosome make-up, now being initiated by Rajindar Pal (1947).

Differences in vectorial status within a single species are well known to exist. In the case of the *maculipennis* complex (317–319) these are shown to be due to the name being applied to what is really a group of species, though whether the seven Palæarctic forms are a *rassenkreise* or full species even Huxley leaves undecided.* Their distributional differences are ecotopic rather than ecogeographical. In all other species showing the same phenomenon the causation is still to seek. In the Oriental Region, with which the present author is most familiar, the following cases have been distinguished† :—

A. culicifacies.—A potent vector in the north-west frontier of India and in Ceylon. Normally a weak vector, carrying by virtue of great numbers in the Gangetic Plain, the table-land of the Deccan and the plains of the Peninsula south of the Kistna (Senior White, 1940), but of no importance in the hill tracts of Peninsular India, and on the coastal plain of the Bay of Bengal north of the Kistna. It

* Ungureann and Shute (1947) have recently shown that in three of these forms differences in scale structure exist, showing that these are systematically valid species.

† For neotropical species, *see* Rozeboom (1942). The author deals with the cases of *A. albitaris* and *aquasalis* as examples.

is recorded as a secondary vector only in the eastern sub-Himalayan foothills and in Burma.

A. fluviatilis is generally a virulent vector in the hill tracts of Peninsular India, though even there are differences, as Viswanathan (1946) has recently shown, for areas situated west and east of the Western Ghats Range. North of the Gangetic Plain, which was a sea geologically much later than the appearance of mosquitoes in the cretaceous age, the species extends to the Upper Tigris and to Russian Turkestan, but has nowhere been incriminated as a vector. In many places *fluviatilis* occurs together with the very closely related *A. minimus*. In Peninsular India both are virulent vectors, but in the sub-Himalayan foothills (Covell, 1938-39), in localities where both species are common, the intense malaria is the work of *minimus* alone.

A. varuna.—A serious vector in the hills of the Indian Peninsula. On the plains below, with the single exception of Western Bengal, it is of no malariogenic importance whatever. On material furnished by the author, Chandrasekar of the All-India Institute of Hygiene carried out the statistical analysis of a long series of egg-measurements. He thought at first that he had distinguished four forms, but in his last communication, he withdrew the claim, as there is a morphological overlap (p. 160 *f.n.*) and it would thus appear that this most important epidemiological difference, which enables *varuna* to be completely ignored in malaria control on the plains, has not even statistically morphological status. The difference in status must therefore lie in the forms of the hills and the plains being biological races (crypto-species) incapable of any ocular differentiation.

A. jeyporiensis has a variety *candidiensis** which is a vector of importance in Indo-China and apparently in the Arakan District of Burma and extreme South-East Bengal.† The type form has been found with sporozoites in the South Indian State of Travancore, but elsewhere has only shown oöcysts. Whether the variety can with certainty be distinguished morphologically seems doubtful, but certainly the form of the Malayan Sub-Region is a successful vector whilst the Indian form is not. The two forms have no common distributional frontier.

A. maculatus.—A common foothill species throughout the whole Oriental Region. In India it is of no vectorial importance whatever, save in Shillong Town in the Khasia Hills of Assam. Further east in the Malayan Sub-Region it is a vector in the hills of Indo-China. In the Malay Peninsula and Indonesia it is the chief vector of the hill ranges and the sole cause of malaria of the rubber estates situated above the coastal plain of the Peninsula.

A. sundaicus.—A species which can cause the most fulminating epidemics, and yet at other times can apparently exist without damage to health, as Gater and others (1929) have recorded from Malaya. The difference in behaviour is not geographical, for there is no part of the species-range where it does not, upon occasion, cause malaria, nor any part where it is always innocuous. Thus the statistically morphological differences which have been found between Malayan,

---

* See p. 175, *f.n.*, for objections to this term.

† Publication of wartime experiences in this hitherto little-known area is a great desideratum.

Indo-Chinese and Indonesian forms by King (1932) do not serve to explain the differing behaviour.

A. tessellatus.—A species of absolutely no malarial significance anywhere save in the Maldive Islands, where it appears to be the only local species, and is the cause of malaria which, during the war, was of significance.

Now the author (Senior White, 1947*a*) has shown, in the case of some of the Indian species, that there are striking differences in the anthropophilic indices and in the relative numbers captured resting near human and bovine blood, and in the open, within the one species in different localities. Such differences, though they elucidate differences in local vectorial status, afford no explanation for the differences in behaviour. In some cases biological races, indistinguishable on morphological characters, obviously exist. With regard to *A. maculatus* its vectorial status in Malaya may be due to the lack of a blood supply alternative to man, through the paucity of bovines caused by the absence of grasses edible by cattle. In such conditions any species which is facultatively anthropophilic must be driven entirely on to man for its blood supply, and there is no need to postulate an ecobiotically distinct race. On the other hand, as will be shown later, there is the possibility that races do exist in *maculatus;* and such must be invoked to explain Schüffner's success and failure, in different areas in Sumatra, to divert *A. hyrcanus sinensis* from man (Hackett, *loc. cit.*).

The concept of crypto-species, or biological races, is perhaps not sufficiently appreciated by malariologists generally, but to Huxley their existence is so well established that his statements are given the force of axioms. Since in our present state of ignorance few mosquito analogies, other than those just set forth, can be advanced, Huxley's statements on the subject are merely tabulated below:

Much of specification is concerned with invisible, physiological characters (p. 153 *f.n.*).

Groups may remain perfectly distinct though morphologically indistinguishable... Sometimes biologically adapted forms are also geographically separated (p. 299).

Differences in ecological preferences may isolate groups as effectively as geographical barriers or spatial distance. Often with the production of 'cryptic'-species (p. 130).

Of birds.—Differences in voice and behaviour are to be regarded as of equal or greater importance than those in morphological characters (p. 158).

Complete physical and genetical isolation may exist with slight or no character differences between the types (p. 160).

When ecological divergence of the two forms has occurred within the same geographical area...spatially overlapping groups may be kept from interbreeding by slight differences in mating habits, food preferences, or breeding dates, and so remain separate in spite of complete, or almost complete, absence of morphological differences (p. 166).

Certainly in most phyla, and probably in all, there exist groups of individuals which are undoubtedly distinct species in every sense except the accepted morphological one (p. 316).

Accepting these axioms as applicable equally to mosquitoes as to other animals, one can but ponder on how many crypto-species lie hidden in the 'portmanteaux-names' of current systematic nomenclature. None the less we agree that **if it is impossible to distinguish forms on the basis of preserved specimens it is of dubious utility to give them separate specific names (p. 166).** This however forces discussion into rather lengthy particularizing phraseology.

Trivial and apparently useless differences between geographical races are accompanied by physical and reproductive differences of great significance in relation to climatic conditions.* *Drosophilia funebris* **in Europe showing no visible sub-species is geographically differentiated into three strains in regard to temperature-resistance (p. 191).** Sufficient meteorological observations, including water temperatures, might reveal biological races in *A. maculatus* adapted respectively to the very even conditions of Malaya, the cool climate of the sub-Himalayan and the fierce heats of Peninsular India (*vide infra*). It is certain that the statement, **the analysis of invisible physiological characters, and the more intense study of visible ones will reveal that species are much more diversified geographically than is now recognized (p. 203),** is as applicable to mosquitoes as to any other group of animals, for example, **the exhaustive analysis of the physiological peculiarities of two morphologically indistinguishable local populations of the water snail,** *limnæa columella*, **shows that they differ quite considerably in inherent mortality and longevity, fecundity and rate of growth (p. 236).** Such differences between two local populations of the same anopheline would produce differences in infection rates quite as definite as would differences in anthropophilic index.

'Physiological ecobiotic differentiation' is the term applied to **the divergent adaptation of separate groups of parasites or phytophagous animals to particular hosts or food plants. All gradations are found from incipient physiological sub-species to full species characterized by complete intersterility and morphological differences. The visible morphological divergence lags further behind the invisible, physiological (including the reproductive) than in any other type of differentiation (p. 295-6).**

Adult mosquitoes are, with few exceptions, parasites of vertebrates. The few exceptions, and nearly all the larvæ, are in the main phytophagous. As regards the blood preferences of the adults, so long as it is possible to work only with human and bovine anti-sera, there will be (Senior White, 1947*a*) a large number of negative reactions which may be due not only to bad, over-digested, specimens but also to the mosquitoes having fed on bloods for which anti-sera do not exist or have not been tested. To what extent feral mosquitoes feed upon the smaller animals of their environment is quite unknown. As regards the plant preferences of the larvæ, opinion is at present apparently in favour of their being nearly indiscriminate feeders, the apparent differences found by the first workers on this subject being possibly no more than a correlation between individual mosquito

* Roubaud (*Bull. Soc. Path. Exot.*, **38**, p. 300, 1945) states that in *C. pipiens anteganicus* form *sternopallidus*, heavy oöcyst infection retards oviposition, and that the first batch of eggs laid after the infecting feed is reduced by at least one-third.

species and the floras of their preferred breeding waters. The whole subject requires *de novo* re-investigation.

The biological races of the moth *Hyponomeuta padella* are suggestive. **One race is adapted to apples, the other to hawthorn and blackthorn. There are no separatory structural features, though there are slight colour differences. The apple form is usually a leaf miner in instar I, the other not. The apple race usually pupates in neat rows with a dense cocoon, the pupæ of the other race are generally scattered with a flimsy cocoon. Moths given a choice of food plants for oviposition show a decided but not absolute preference for their normal host, and even the hawthorn and blackthorn sub-races are separable on the basis of their egg-laying preferences. Larval preferences are marked but not fixed, they can be altered by starvation to the 'wrong' food though the resulting imagines are generally undersized and infertile. The mating preferences are only relative, though the attraction between individuals of the same race is about twice as strong as between those of different races (p. 297).** Such a case would appear very germane to the fears of 'species deviation' which sometimes arise when a species driven from its usual breeding waters by control methods appears in unusual water collections. No one appears to have considered whether when *maculatus*, driven from ravines and seepages, appears in rubber planting-out holes or old tins, the resulting imagines are fertile. If they are not, there is no fear of the establishment of dangerous new breeding places.

The leaf hopper *Cicadulina mobile* **is divisible into two races solely by ability or inability to transmit the virus of 'streak' disease in maize. The difference, a single gene, is concerned with the penetrability of the gut wall by the virus (p. 312).** Substituting 'ookinete' for virus, we arrive at a genetic explanation for Huff's (*loc. cit.*) vectorial and non-vectorial races of *C. pipiens.*

Adaptation is as often manifest internally as externally, in improvement of some physiological function as in better adjustment of some obvious external character to the environment. The adaptation of parasites to their hosts comprises a wide range of physiological features, among with the degree of virulence may be singled out (p. 429). The last statement would apply to the extrinsic cycle of a parasite only, for there appear to be few cases in which the intrinsic cycle is injurious (*W. bancrofti* in excessive numbers may kill *C. fatigans*), for oöcysts in great numbers do not appear to harm mosquitoes. Genetic analysis of closely allied vector and non-vector species, and the gene differences underlying the Mendelian segregation of vectorial capacity at present only revealed for *C. pipiens* by Huff (*loc. cit.*) is called for.

The hydrocyanic acid control of various scale insects, pests of citrus fruits, has resulted in the selective survival of cyanide-resistant races in three important species of coccidæ. The codling moth has strains differing markedly in the capacity of their larvæ to enter apples sprayed with lead arsenate, and raising a suitable strain on sprayed fruit in the laboratory can increase from generation to generation the percentage resistant to arsenic. Resistance of the red scale of citrus to cyanide is genetic, and it remains unaltered after many generations. The cyanide-resistant strain, moreover, has shown itself more

resistant to other toxic substances (not cyanides), to which it has not been exposed by orchard treatment. Thus the newly evolved resistance appears to be a general rather than a specific one: the same is true of the codling moth (p. 471-2). The creation in insects of these man-made poison-resistant biological strains, following on the long-known creation of arsenic-fast strains of the trypanosomes of sleeping-sickness by undertreatment with atoxyl (Manson-Bahr, 1935), raises problems of the utmost importance in respect of substances used for both larval and adult mosquito control.* Using both oil and paris green larvicides the inspecting officer accepts the existence of the odd survivor without adverse comment, as such is supposedly protected, as is indeed often visibly the case, by floatage or cover. Oil has now been in general use for over forty years, and paris green for twenty. No such phenomenon as above recorded for orchard pests of two widely separated orders has been so much as suggested for mosquitoes, but when we pass from larvicides to adulticides, we enter upon the effect of chemical weapons which have been in general use for much shorter periods of time. In regard to pyrethrum, in the course of control work of the usual standard, it is so difficult to ensure the penetration of the spray cloud into every crevice in which a mosquito may find daytime refuge that the odd escape may owe its survival to insufficient penetration, and any developing resistance would therefore be masked. In regard to D.D.T. and gammexane, chemicals almost of yesterday, lethality having a definite time-contact factor, and a disturbed mosquito being so liable to change its point of rest from a treated to an untreated surface (Senior White and Ghosh, 1946), the survivors found over any period which has been lethal to the majority of the house population may be merely particularly restless specimens. On the other hand it would be useful to collect and breed from such specimens as may really survive, and not merely be found to undergo a longer period to death, to see if any chemico-resistance effect can be detected. If there is the least indication of such developing,† the ultimate abandonment of such substances must force the world into biological methods of breeding control, since such will finally be the only method of mosquito control left to us.

Having thus convinced the malaria worker of the existence of biological races indistinguishable by the usual classificatory methods, we must now pass to the consideration of certain principles of genetics. These concepts are fundamental to any understanding of the subjects which follow.

Mutations are random with regard to evolution. They produce changes unrelated to the direction of evolutionary change in the type, or the adaptive or functional needs of the organism. In most species some mutations occur in IXIo^5 individuals. Many genes have a mutation frequency of IXIo^6 (p. 54).

* Whilst this MS. was under preparation, Bishop and Birkett (1947) and Williamson, Bertram and Laurie (1947), in two preliminary announcements (*Nature*, **159**, pp. 884–886), have shown that acquired resistance to paludrine against *P. gallinaceum* can be induced in chicks, and that this resistance is cyclically transmitted through *Aedes aegypti*. Both sets of workers also show that this acquired resistance extends to '4430', the methyl homologue of paludrine. The resistance did not extend to mepacrine, quinine, sulphadiazine and '3349'. Bishop and Birkett suggest that the explanation for the resistance may be either the selection of favourable mutants, or the gradual adaptation of the parasites to the drug.

† Since this MS. was written, such have appeared, both in mosquitoes and houseflies (Missiroli, 1947).

This means that in every million or less individuals there appears one which possesses some character different from the rest of its group. If the character confers benefit on its possessor, the specimen is more likely to survive and to pass on the character, if dominant, to its offspring. **Even if the new character is selectively neutral, it will establish itself in half the individuals in 10^5 generations, but if it confers an advantage of only one per cent, it would establish itself in half the individuals in only 10^2 generations (p. 56).** But **a reduction of 0·1 per cent in viability would result in adverse selection which would override mutation at the highest rate ever observed in nature (p. 123).** Only a few mutations are favourable to a species. As a mosquito under optimum conditions has about twenty-four generations a year this means that some useful mutation, which does not affect viability adversely, would spread through half a population in little more than four years. It is suggested that it was such a mutation, possibly back to a recessive character long hidden in the genetic make-up, that enabled *A. sundaicus* in its invasion of the North Madras Coast (Senior White, 1947*b*) to invade fresh waters over twenty miles inland. Evidently such a mutation was not available to the race evicted from the fish ponds of Batavia in Java by Walch (Hackett, *loc. cit.*) in what is, even after nearly twenty years, the most outstanding example of biological control yet accomplished. Here it was feared that the species when evicted from the very saline fish ponds would colonize extensive less saline marshes further inland. This however it failed to do. But Java is in the very centre of the area of *sundaicus* distribution, whilst the East Coast of India is at its margin, and **the marginal zones of species are often characterized by a peculiar population-genetic structure or by special adaptations (p. 129),** for **primitive types tend to be preserved near the margins of the range of a group (p. 377)** and *sundaicus* may, on the analogy of the closely related *ludlowi*, have originally been a species of fresh water. Thus, as *sundaicus* has recently invaded Celebes, it may presently be expected to spread to the Philippines, unless it there finds its saline and fresh water ecotopes, now occupied by its close relatives *littoralis* and *ludlowi*, so fully stocked that it cannot dominate or even enter upon them. If it does enter it will render malarious large areas of the Archipelago, at present healthy, as the only local vector is the sub-montane stream breeder, *minimus* var. *flavirostris*.

The greatest amount of evolutionary potentiality is available to large species divided into partially discontinuous sub-species (p. 60). Sub-species are most likely to arise where a species finds itself separated into isolated groups, as particularly occurs (p. 323) **in oceanic faunas** where **decreased selection pressure permits increased variation.** Taking again *sundaicus* as an example we find it, in Peninsular Malaya, is continuous in its distribution, which also appears to be the case along the coasts of Indo-China, though apparently suitable ecotopes exist that are unoccupied. Until the species invaded India, the rest of its area of distribution was insular, albeit that this area includes some of the largest islands in the world, where the fauna cannot be considered as 'oceanic'. Discontinuity in distribution is however obviously largely ecotopic, as suitable estuarine conditions are seldom found without considerable separatory areas, thus creating isolated ecotopes equivalent to island conditions. The immense deltaic area at the head of the Bay of Bengal must be the largest continuous ecotope available to the species. But if the area occupied by a thus isolated population is

small, then **accident, playing a part in the survival of particular genes or gene-combinations, is enhanced in small populations. In small species or sub-species useless or even deleterious changes may become constitutional through chance recombination (p. 58).*** It will be at once objected that in *sundaicus* there is no evidence of the existence of sub-species. Whilst morphologically this may appear to be so, biologically this is not the case, as its vectorial behaviour both in India and Malaya shows. Due to the investigations of malariologists being perforce confined to such small spots within the area of distribution of any anopheline where the particular species is of health importance, how patchy and to what extent related to blood supply for the adults the general local distribution may be, is completely unstudied. A *sundaicus*-caused outbreak in an isolated village usually occurs suddenly, and frequently dies out after one or two seasons. If the local area of distribution around such a village is really only the **activity range (p. 238)** of the adult population feeding on that village, as restricted by the flight range between the breeding places and blood, then such a village is ecologically an island, and the Sewall Wright effect will occur, for though **a large species may become broken up into slightly differentiated sub-species adapted to local conditions but inter-breeding to a certain extent with neighbouring species† really isolated small local groups, not inter-breeding with the rest of the species, insufficiently variable to respond readily to selection, may evolve useless or deleterious characters, and be more prone than larger groups to be extinguished by altered conditions (p. 43).** 'Altered conditions' in mosquitoes will be in the main climatic, and may be cyclical in appearance.

Whether mosquitoes normally actively migrate or are purely passively transported further than the normal activity-range of their species, by wind or by human agency, as in the outstanding example of the invasion of Brazil by the Ethiopian *A. gambiæ*, is uncertain.‡ Either mode of location-change must help the species for the **impulse to migrate in unfavourable conditions confers plasticity on a species by increasing the range of environmental opportunities available to a given hereditary constitution. Unfavourable temperatures (or other climatic factors) will thus increase the genetic variance available to a population (p. 85).** Again **during the period of rapid increase, numbers low and conditions favourable, the intensity of selection will be very low. During the peak period intra-specific selection due to competition will be very high. During a catastrophic fall in numbers selection will be mainly concerned with disease-resistance. During the subsequent period of unfavourable environmental conditions selection will be concerned with the struggle for existence (p. 111).** With mosquitoes substitute 'unfavourable breeding conditions' for 'disease-resistance'. Diseases in mosquitoes, larval and adult, are very rare and never epidemic or catastrophic. **With this less extreme type of migration many individuals will survive temporarily in regions beyond the normal range and be able to return later to their original habitat, but some individuals may be able**

---

* This is the 'drift' phenomenon of Sewall Wright, on which, throughout his book, Huxley lays frequent stress as being one of the most important biological discoveries of recent years.

† I take this to be a *lapsus calami* for 'sub-species'.

‡ Pre-hibernation migration in *A. elutus* has been described and studied by Kligler. These flights spread malaria to villages otherwise free from the disease.

to survive and remain in areas outside the normal habitat, either by adopting slightly different habits and so colonizing different habitats within the original range, or by colonizing areas outside this range (p. 114).

Taking the quotation from page 85 as axiomatic we see how in a cycle of prevalence as described in the quotation from page 111 a hardier form will eventuate. In the first *sundaicus* outbreak in deltaic Bengal the species spread rapidly on the right bank of the Hooghly over the five-mile stretch where apparently alone it encountered completely favourable ecotopic conditions. Passive migration by train at that period carried the species eastward from the invaded area into the suburbs of Calcutta, but though instances of breeding outside the five-mile stretch were found, these small foci always speedily died out. After the apparent disappearance of *sundaicus* from the entire area in 1940–1944, the subsequent reappearance seems to have been of a race more adapted to spread into localities which during the original invasion could not be colonized, for it was found in sufficient density to cause malaria outbreaks for fifteen miles west and the same distance east of the original invasion point. It is most unfortunate that during the *gambiæ* invasion of North-East Brazil those concerned had quite understandably no time for anything except survey followed by immediate control. In a species occupying ecotopes in which it had absolutely no competition from the indigenous species of anopheles, and in which any enemies must have been general rather than special, the pullulating production that occurred, unchecked by selection or by efficient enemies, must have thrown up every kind of variation. Due to the thoroughness of the control measures it is doubtful if anywhere a natural 'peak' period was reached, whilst the catastrophic fall in numbers—to extinction—that followed was due to chemical warfare against larvæ and adults that was completely indiscriminate.* A unique opportunity for research that it must be hoped is never likely to recur anywhere in the world was perforce lost. That during the years of the invasion *gambiæ* proved unable to invade areas with ecoclimates widely different from any existing in its African home tends to show that there are definite limits beyond which even a mutation-rate in which every non-lethal mutation could flourish unrestrictedly will not enable a mosquito with even the catholic tastes of *gambiæ* to colonize zones of a completely different ecology.

Thus whilst abundant species will have greater evolutionary plasticity, a higher potency of adaptive change, rare species will tend to become sub-divided into discontinuous groups which, once isolated, will have a greater likelihood of differentiating into separate species, abundant species will differentiate into sub-species in different parts of a continuous range. Migration will keep distributing genes from one sub-species to its neighbours, and thus variability will be at its maximum (p. 33). In a given time a rare species cannot lay its hands on the same store of mutations as an abundant species (p. 57). Competition in rare species will be between the species as a whole and its environment, or between it and other related species, whilst in abundant species selection will be between individual member of the same species (p. 34).
What constitutes a 'rare' species, and why should such be so? Dr. S. L. Hora once remarked to the author 'there is no such thing as a rare species, you only

---

* Missiroli (*loc. cit.*) doubts whether the eradication of the species from Brazil was entirely due to human effort, but gives no data in support of this contention.

don't know where to look for it!' This is frequently true from the viewpoint of general collecting in an order or even a family, but as regards the culicidæ, where in most regions every form of water has been frequently and meticulously searched for larvæ, and both routine and special survey collections of adults are frequently made, 'rare' species appear undoubtedly to exist. In the fauna of the Indian plains *A. majidi* and *A. moghulensis* may be classified as rare and both as larva and as adult very little is on record about their biology. When the hill tracts are reached, however, there are definitely 'rare' species encountered, albeit that above the malaria limit very much less collecting occurs. *A. pinjaurensis* is only known from one locality, the hillfoot Pinjaur Gardens on the Ambala-Simla Road. *A. habibi* is an equal rarity from the mountains of Baluchistan. The hill-stream breeders *gigas* and *lindesayi* are admirable instances of the fact stated on page 33 *f.n.*, that rare species will tend to become sub-divided, for each has five Asiatic sub-species sufficiently well differentiated morphologically to be named. The two species are considered to be relics, isolated on hill tops after a general climatic change that wiped out their distributory connections, and in full ecotopic isolation have developed into these well-defined sub-species, the ecotopically very specialized tree-hole breeders are in India dependent upon a montane tree-flora liable to rot-holes which is almost absent from the plains. There are very numerous culicines in this fauna, which among the anophelines is confined to the Palæarctic *plumbeus barianensis* in the Western Himalaya and to *annandalei* in the eastern sector of that range. Beyond India, the two sub-species of *annandalei* lead on to *asiaticus* of the lower foothills of Malaya, breeding only in bamboos pierced between the septa by a boring beetle in such a fashion as to hold rain-water and admit the mosquito.

Outside the Oriental region the Neotropical *bellator* and other species of the sub-genus Kerteszia have another specialized ecotope, rain-water in the axils of Bromeliads. The first being the major vector in the cocoa-growing area of Trinidad cannot now be classed as 'rare', for the Erythrina trees used locally for cacao shade are preferred nidi for the Bromeliad species in which *bellator* breeds, creating a most interesting instance of 'man-made' malaria. In the Oriental region the ecotopic niche of rain-water in leaf axils (including the non-indigenous pineapple) is occupied by rare culicine genera such as Heizmannia and Tripteroides, and both in the Oriental and Ethiopian regions that extraordinary genus Harpagomyia, which as an adult is myrmecophilous.

There are, in the category of species with specialized ecotopes, in every region a set of halophilic species: *elutus* and *multicolor* in the Palæarctic (the latter also in fresh water in Palestine): *sundaicus* and *baezi* in the Oriental (the former also facultatively in fresh water in India, though still unable to establish itself at any great distance from the sea, perhaps on account of a need for an equable ecoclimate). In the Ethiopian region, *A. melas* and *A. dancalicus*, the latter stated by its describer to breed, as can *multicolor*, in brine pools so concentrated as to be marginally crystallizing. The Nearctic *atropos* has both saline and fresh-water forms, whilst the Neotropical *aquasalis* is a major vector in the Caribbean sub-region. In the Australasian region, *A. farauti* breeds in water of up to 65 per cent of sea concentration and New Zealand culicine genus Opifex actually breeds in small rock-pools of sea spray. Most of the anopheles above mentioned have close relatives

in fresh water, and it is noteworthy that these are often less potent, or non-vectors, whereas the saline species are most of them major vectors. Major vectors can never be 'rare' however. **A single gene may affect a number of characters (pleiotropism). In drosophilia (p. 62) eye colour genes affect the shape of the spermatheca and the colour of the testis sheath (pp. 80, 533).** A single gene-difference may therefore presently prove to be responsible for profound differences in both larval ecobiology and adult vectorial capacity. Similarly in *Stegomyia aegypti*, Willcocks (1946) is finding 'that populations of the same taxonomic group may differ markedly in response to (Y. F.) virus and that these variations may exist in the same area at different times. Inevitably epidemiology develops genetic factors for complete understanding'. These investigations will undoubtedly throw a new light on outbreaks of yellow fever, and inferentially on those of malaria also. A concatenation of meteorological conditions favouring heavy breeding, combined with a reduction in immunity in the human host, may thus prove to be not the only cause of fulminant malaria. But at present these are pure speculations, merely made to indicate the immense field that lies open to any investigator who can work with anopheles bred in continuing generations, as can now only be done, without large and costly cages, for a few stenogamic species.

Divergence of two stocks will involve the accumulation of different genes in the two lines, and will lead to some disharmony on crossing, the F_1 or later generations being less fertile or less viable (p. 68). This is one of the causes of inter-sterility between species, but the implications of the fact are great. Two stocks which for any cause have passed some way along diverging lines at any stage in their life-cycles are not likely to recombine successfully into a single uniformly-behaving line again. **Variation in the environment often leads to selection of certain types from among the range occurring naturally. This may refer to either continuous or discontinuous variations (p. 120).** Deforestation ,and the opening up of land, training of streams resulting in swifter flow and related changes in their general fauna and flora, etc., all have well-known repercussions on the anopheline species of an area. Such may be for good or ill in their effects on the local malaria. A strongly vectorial stock, possibly through changes in the anthropophilic index, having, through meteorological or other causes affecting breeding, become dominant at the expense of a less potent stock, may, when breeding conditions return to normal, after a period of special fertility, occupy the biotopes to the partial exclusion of the latter. Though the post-epidemic immunity developed in the human survivors may for a few years mask the development of a more efficiently vectorial stock, this, once developed, cannot again merge with the less efficient, and it is likely that after an epidemic a new and higher level of malaria incidence will occur. Artificial variations in the environment is the underlying principle of biological species control (Hackett, Russell, Scharff and Senior White, 1939). To date alteration of the environment has been directed to favouring a non-vectorial species in the replacement of a vectorial, but from the examples Huxley gives in support of his statements, it is obvious that with sufficient knowledge the procedures might be directed towards favouring a less-vectorially potent race within a single species, where or when such a race can be distinguished. A race might prove easier to change than a full species.

The spread of genes will be different in linear populations (rivers or shore lines, essentially unidimensional) from what it is in the usual two-dimensional species (p. 162). This is true for all mosquitoes other than species whose larval habitats are in weed-covered pools and marshes with breeding edge throughout their surface, and the species of artificial water collections. For though the adults, which spread the genes, range from the breeding places to the limits of their flight range, a line tangential to these limits is still linear and parallel to the river banks, even though the area between the bank and the tangent is wider than that of the breeding strip. Everyone who has done larval collecting along a stream knows that the distribution and density of breeding vary very widely from point to point along the banks. Small, semi-isolated, larval-population groups therefore exist, from which imagines will fan out semi-circularly as far as the activity range. Gene-flow between such groups can only occur where the semi-circles of the individual activity ranges intersect, and the less the areas of intersection, the slower will be the extent of gene-flow. So far, however, no work appears to have been done (*a*) on whether specimens from a single breeding place have a homing instinct to return to it for oviposition or go to any other suitable breeding place available within the flight range of the adult feeding spot or (*b*) whether micro-sub-species exist along the course of a river. They may in certain cases well be expected to do so, for if the species concerned is strongly but not absolutely anthropophilic, and the villages along the stream are well separated, then groups of individuals originating from beyond the activity range to human blood must have undergone selection tending to the development of a higher tropism for non-human blood. On the other hand Adisubramaniam and Vedamanikkam (1943) have produced evidence that in *fluviatilis* breeding is concentrated along such a stream, within flight range of the villages, and that without a human blood supply breeding of this species at least cannot flourish.* Crypto-sub-species may therefore be present, but it should be borne in mind that **recombination must also be at work in the zones of simple intergradation between sub-species that differ only slightly and in quantitative ways (p. 161).** This statement appears contradictory to that quoted from p. 120. The existence of the phenomenon suggested above would have to be sought in specially chosen localities. If found it would afford further period of the theorem enunciated on p. 154, **that with ecological differentiation the primary factor is divergence in functional specialization, which may lead to full specification with complete biological discontinuity within one geographical area.** Functional specialization, as revealed by differences in anthropophilic or other blood index, might well produce no apparent morphological differences. The point has been further discussed in connection with biological sub-species.

Related ecological species tend to be characterized by detailed adjustment to special habitat and mode of life, and often by special adaptations to prevent intercrossing ...... ecological specification is encouraged by a decrease in biological competition (p. 155). Here we are considering the case in which full specification has been reached. Among anopheles, we may instance *aitkeni* (with three morphologically differentiated sub-species) and *insulæflorum*, or

* Rao and Philip (1947) have recently produced contrary evidence for the same species.

A. maculatus (with two sub-species) and *theobaldi*. The stream habitats* of the two groups differ apparently only in amount of shade cover, but within either of the two groups there has not been sufficient observation to discover detailed differences in the ecology of the sub-species of the two species. A quite unexplored field for observation therefore exists. It was thought that between *maculatus* and *theobaldi* minute larval differences exist which may be statistically distinguishable. An adult which was '*maculatus*' by one hind leg and '*theobaldi*' by the other was once bred. Possibly the two species occasionally intercross, but the specimen may have been only a colour aberration. The range of *theobaldi*, Central India, is very much more restricted than that of *maculatus*, and lies wholly within it. This may be a case **where a single species as a whole may be transformed gradually to such an extent as to merit a new specific name, or it may separate, also gradually, into two or more divergent lines transcending the limits of specific distinction. The separation into mutually infertile or otherwise distinct groups may occur suddenly. But the subsequent divergence may yet be gradual.** As regards the sub-species into which one of each of the pairs under discussion is divided (p. 185), **the main differences between sub-species are of genetic origin, and are not due to environmental modifications.** Whether these sub-species are on the way to full differentiation will depend upon (p. 210) whether they come into the category of (*a*) **independent, i.e. so fully isolated that gene-flow between them and other groups is wholly or virtually interrupted, or (*b*) dependent, interbreeding with their neighbours along intergrading zones. (*a*) may differentiate into full species (p. 170). (*b*) normally will not do so.** The separation between *maculatus* and *theobaldi* appears to be ecoclimatic; *theobaldi*, in its toleration of high saturation deficiency caused by little or no rainfall at the season of maximal temperatures, appearing to be more specialized than *maculatus*, but though considerable data exist in the weekly check catch records of my former department, they have never been abstracted to see whether seasonal fluctuations exist in the proportions of the two species in Central India. The species group is certainly less common in the hot than in the cold season, but whether *maculatus* and *theobaldi* is heterodynamic in Central India, as the former is in the much more equable climate of Malaya, has never been investigated. Clines in *maculatus* are discussed subsequently. The nature of the separation between *aitkeni* (*s.l.*) and *insulæflorum* is even more obscure. *A. aitkeni* probably extends further westward than race *bengalensis* or *insulæflorum*, but too little collecting has been done for certainty, and the whole group appears to extend to the Australasian region. The separation between the various forms is not primarily geographic and, if ecotopic, will require much more detailed observational larval collecting than has so far been done.

Ecological specification within the same region will accentuate the degree of character divergence in those promoting associative and impeding inter-specific mating. Ecological but spatially overlapping differentiation will promote divergence in general characters, since more complete adaptation to the two ecological niches will be advantageous to both species (p. 295). In the two groups just discussed divergence is seen in morphological characters,

* *Maculatus-theobaldi* also breeds in seepages.

but are entirely, as just stated, without information as to the 'ecological niches' occupied by the individual forms. Even the extensive investigations of Swellengrebel and de Buck (1938) in Holland have not entirely elucidated the ecological niches occupied in that small country by *messeæ* and *atroparvus*. With the paucity of observers in the tropics it seems likely that decades will pass before groups of species such as have just been discussed will come under intensive study. The scientific amateur, on whom much of such observation must depend, is almost entirely the product of Europe and North America. The 'niches' will require detailed microphysical and chemical work for their elucidation, much of it beyond the purse, if not the training, of the amateur. Would that more retired professional workers could emulate Falleroni, but in this post-war world the retired worker is generally too preoccupied in keeping alive to be able to follow scientific pursuits for pleasure.

Recently Fennah (1946), writing on the Insect Fauna of the Lesser Antilles, has stated (for the Fulgoridæ) that variations in male genitalia 'raise no mechanical barrier to copulation between the sexes of allied species', and after this revolutionary statement,* proceeds to hypothesize on an 'imponderable factor of a physiological nature' as a bar to cross-mating. Rao, Roy and Rao (1942) have observed the individuals of a mixed swarm of *subpictus* and *sundaicus* selecting their specifically correct partners in a general mating dance, in spite of the quite close build of the male genitalia of the two species. This strengthens Fennah's assertion which, however, would not appear to have been tested by experimental cross-matings, as has been done with the *maculipennis* and *stephensi* complices in anopheles, only to prove that the forms in these complices are biologically good species. Fennah's 'imponderable factor' is probably related to what Huxley so usefully calls the 'ecological niche' occupied by such species, 'fixation of habit lending to reproductive isolation' (Fennah).

In regard to specific mating reactions in which the bar to cross-mating is not absolute, **in drosophilia no example is known where different species will mate as readily as do individuals of the same species. Races 'A' and 'B' of** ***pseudo-obscura*** **almost certainly differ in the male stimulating scent. They show a marked lowering of fertility on crossing, F_1 males being wholly sterile, the females being only slightly fertile. This illustrates (p. 292)** that **mating barriers of special type will tend to be erected between closely related species which show spatial overlap (p. 288).** When the *maculipennis* and *stephensi* complices are cytologically explored similar chromosomal differences may emerge, and from such a starting point such cases as *aitkeni-insulæflorum* and *maculatus-theobaldi* may become less puzzling than they now appear. The case of the *maculatus* complex would seem particularly worth exploring, but so far no one has succeeded, even if anyone has really tried, to achieve continuous breeding in even such a common and important species as *maculatus*. It must be remembered that **geographical segregation in insects is often of a different nature to the more familiar process observable in birds and mammals. Non-geographical, i.e. ecological or physiological, forms of isolation can be much more effective in insects, a conclusion borne out by the abundance of 'biological races' in the**

* Also Robson and Richards (1936), pp. 155 and 299.

group, as contrasted with their total absence, in any strict sense, in higher vertebrates. Experimental analysis of such cases is urgently needed (p. 321). Experimental analysis, as has been stressed throughout this paper, must involve continuous breeding of isolated lines. Breeding of eurygamous insects is very difficult, and the facilities required costly. The evolving of a successful and, if possible, inexpensive method would well repay the cost of the trials.

Within the species and below the categories of 'sub-species' and of 'race', is the (p. 206) cline, a term defined to cover the frequent tendency of intra-specific characters to change gradually and continuously over large areas. **They appear to be much commoner than is generally supposed. The adaptive characters directly affected may be visible ...... or they may be invisible, physiological features with no outward sign in the characters usually employed in taxonomy. Broad environmental gradients exist in numerous general climatic factors ...... more restricted gradients are found in ecological factors ...... gradients in salinity, water content, height of vegetation, edaphic conditions, and so on.**

The three strains of *D. obscuripennis* form a cline, rather than sub-species or races, as their physiological peculiarities intergrade on their distribution frontiers. This is an instance where '**the genetic peculiarities of the geographical race harmonizes the life-cycles of the animal, especially the feeding season and the 'diapause', with the seasonal cycle of the inhabited region (p. 383). Groups separated ecogeographically are species only** *in posse*. **Divergence is normally slow. In** *D. pseudo-obscura* **(p. 436) the forms 'A' and 'B' differ in various physiological characters, such as temperature-resistance; they probably still exchange genes in nature (p. 369).** (On p. 323 it is stated that they are inter-sterile.) **They are characterized by sectional chromosome arrangements which could only have originated in isolation. Though they have different geographical distribution, they overlap considerably. The divergence leading to intersterility first occurred in a local group, which was later able to invade the other's range. Within each race there are 'strong' and 'weak' forms differing in their sex-determining mechanism. The two races (incipient species) can only be distinguished by statistical analysis ...... such species can only be detected by refined and detailed systematic methods, and will often not be recognized by systematists who are not alive to the implications of genetics (pp. 323, 383, 359, 369).** These statements are suggestive in respect of *A. maculatus*, which may be found to have a cline for humidity-tolerance running from Malaya to Central India, and another for temperature-resistance running from Central India to the sub-Himalaya. Even in Malaya, with its very even climate, the species is hetero-dynamic and there are months of greater prevalence than others characterized by an increased malaria incidence, whilst in Central India, in the hot weather and the ensuing monsoon, the species is rare in routine collections in which, being harmless, it is not especially looked for. **Clines for different characters may run in different directions as suggested above (p. 261). The only way in which clines on a genetic basis may be established over small distances is by a highly variable population, of which different types are adapted to different ecological conditions. Selection will then see to it that different proportions of various types are found along the environmental gradient even when this is quite short. With regard to large-scale clines, the biological peculiarities of the species will**

have an influence, large size and high mobility tending to make them prominent, and *vice versa* (p. 207).

In discussing clines the word 'deme' is defined (p. 203) as **any specific assembly of taxonomically related individuals.** The term would therefore include such categories as 'groups' and 'strains', and should be generally adopted for, e.g. the Malayan, sub-Himalayan and Central Indian populations of *A. maculatus.* It may be concluded that the discussion on clines by quoting **as detailed work proceeds, and is backed by genetical and ecological study, the mapping of character gradients will afford an important method of taxonomic analysis (p. 225).** Clines have never been considered in mosquitoes; they may well, when long series across wide areas have been examined, be found to exist in minor variations of colour, banding, etc., as well as in physiological preferences and tolerances. The increasing adaptation of *sundaicus* on the East Coast of India to fresh water might be no more than a cline extending inland from the sea face, and not due to a mutation as suggested on p. 20. The development rate of clines is unknown.

The definition of the word 'deme' has already been quoted. In malaria transmission the size of the vector-population-deme is one of the major factors governing incidence. The following quotations are apposite to the question of population: **A population approximately constant from year to year is very far from truth for many if not for most species. A 'stable balance of nature' does not exist. The difference in abundance between crest and trough may be very great (p. 110).** In mosquitoes few extended measurements of density within a single, uncontrolled area existed until the recent publications of Ribbands (1944) and of Senior White, Ghosh and Rao (1945). Much more extensive records collected by Senior White exist, and are under statistical analysis by Ribbands. But in respect of both malaria transmission and nuisance-value figures for 'year to year' should be replaced by 'week to week' or even 'day to day' over a season of the year in which any particular species of mosquito is under examination, or is of public health importance. Comparisons between corresponding weeks (e.g. from the start of the rains) are required for correlation with figures for the ensuing malaria incidence. There are in administrative records everywhere very long series of such data in respect of controlled areas, collected as a check on the efficiency of the local control measures, but as these, even with the highest degree of efficiency usually obtainable, inevitably vary in intensity, they are, at least so far as routine temporary measures are concerned, no use in demonstrating natural fluctuations.

In a population subjected to cyclical fluctuations in abundance, the determining factor is the size of the minimum effective breeding population. In extremely small populations the Sewall Wright effect may even fix deleterious mutations and so result in extinction (p. 201). In the absence of larval surveys over areas wider than the activity-ranges affecting individual villages (*vide* p. 11) it cannot be stated whether the anthropophilic populations obtaining their blood supplies from such villages are actually isolated from one another, or have small zoophilic populations connecting the anthropophilic populations centred on the villages. If these latter are truly isolated, then their periodic disappearances over a number of years will well be the result of the Sewall Wright effect, and it will

not be until the vector is re-introduced by active migrations or passive transport that further outbreaks of malaria will occur. The only Indian vector known to thus disappear periodically is *A. sundaicus*, but of non-vector species the author has seen *turkhudi*, in the Central Provinces, appear after some ten years of check catching, become, if not common, then not quite a rarity, for two years, and then again vanish from the catches.

In periods of over-population migration will be initiated and be most intense in the direction of a falling gradient of population pressure. Two contiguous sub-species will thus be pressing against one another like two inflated rubber bags, and the boundary between the two will shift according to the relative degree of population pressure (p. 188). When one sub-species is a vector and the other is not, the resultant of such a movement would be a belt subject to wide fluctuations in malaria incidence, lying between an endemic and a healthy area. The distinguishing of such belts, which would *prima facie* be notable for their existence within the area of distribution of one (apparent) species, should lead to doubts as to the latter's homogeneity. Under the usual conditions of restricted budgets and staff, it is however doubtful whether any data would exist for the healthy area. However, **as crosses between two harmoniously stabilized gene-complexes will give relatively disharmonious gene-combinations, the zone of intergradation will constantly be renewed by intercrossing, but it will be as constantly prevented from spreading by selective elimination in favour of better internal adaptations on either side (p. 209).** The premise of the quotation on page 188 is inter-sub-specific sterility, of that on page 209 of inter-specific fertility, and the rubber-bag simile breaks down.

Periodic fluctuations will promote the migratory impulse which is so strong in an unfavourable condition. Migrations are manifestations of a much more widespread phenomenon, an impulse to react to unfavourable conditions by changed behaviour,* notably by movement away from an environment which has become unfavourable. This does not normally result in mass migration, but in an irregular movement dispersing the population over a wide area (p. 133). As remarked earlier, the first point to decide is whether mosquitoes do actually migrate in the sense that birds and mammals do. The Nearctic Aëdes which invade areas twenty or more miles from their breeding places may only be extreme examples of an activity-range, and the flights of *A. albimanus* across the zone of the Panama Canal first noted by Le Prince and Orenstein certainly come within that category, as there is some indication of a dawn return-flight. The periodic influxes of *Culex gelidus* and the autumnal presence of *A. hyrcanus* var. *nigerrimus* into the almost mosquito-free area of Garden Reach in Calcutta, recorded by Senior White (1934), appear to be actual migrations, but as the breeding areas from which the *gelidus* flights originate have never been located, it cannot be stated whether in them unfavourable conditions are at the time prevalent. Outbreaks of *sundaicus*-caused malaria several miles from coastal breeding foci, as recorded in Senior White (1947*b*), have always been associated with the establishment of new inland, fresh water, breeding foci, often of only transient existence. This may not be due to mechanical transport, by wind or by human means, as discussed

* *Vide* third footnote on p. 21.

in that paper, but to actual migrations, but nothing is known as to whether the permanent foci have temporarily become unfavourable or overcrowded. The breeding density of *sundaicus* is known to fluctuate enormously, and **forms in numerous and relatively isolated local populations, subject to large fluctuations in numbers, may arrive at adaptations having a general instead of local value, and thus tend to displace all other strains by excess migration (p. 479).** But the invasion of the East Coast of India by *sundaicus* is so recent that an influx into fresh water will not be, so far, displacing another strain, but will either be displacing or filling vacancies in the biocoenosium occupied by *subpictus* and/or *annularis*. *A. sundaicus* is a good instance of a species conforming to these categories of numbers, isolation and fluctuations. The 'adaptation', it has to colonize absolutely fresh water, may not be a newly developed character but a primitive one, usually recessive, becoming dominant at the margin of the zone of distribution or the spread of a character along a cline, but in the latter case there should be evidence of a salinity gradient from the sea-face landwards. The capacity to colonize fresh water sometimes appears to exist even near the centre of *sundaicus* distribution, as witness its temporary colonization of a high-elevation inland lake in Sumatra when it escaped from Schüffner's laboratory (Hackett, *loc. cit.*), in spite of its failure to colonize saline areas near Batavia.

Intra-specific selection is commoner than is supposed. An ...... important feature of the struggle for existence is the competition of members of the same species for the means of subsistence and for reproduction (p. 480). Among mosquitoes the example which will at once occur is (Swellengrebel and de Buck, *loc. cit.*) demonstration of the larval elimination of *messeæ* by *atroparvus* in saline waters. But until the exact status of the races of *maculipennis* is settled, this may be a case of inter- and not intra-specific selection.

Specification, so far as it is due to natural selection, automatically protects itself against any likelihood of change, save further change in the same direction (p. 500). A race adapting itself from saline to fresh water will therefore be unable to revert to breeding in more saline conditions, for example:

Many adult characters may well be non-selective *quâ* **adult characters, being consequential results of juvenile adaptations (p. 468).** This opens up the possibility that vectorial capacity, which cannot be selective as an adult character, so long as both forms bite man, may be brought about by larval adaptations that lead to the development in adult tissue of suitability to plasmodial development. The possibility of biological control of malaria by sub-specific and not specific substitution has already been envisaged. If vectorial capacity in the adult is a resultant of larval adaptations to some particular habitat or pabulum, it is a step further towards such an achievement, already foreshadowed by Williamson (1928), in respect of the protein-ammoniacal nitrogen ratio in the waters in which *sundaicus* breeds. In the first place we require **determination of metabolism, temperature-resistance, etc., combined with accurate anatomico-physiological study of respiration and directed by ecological knowledge,** (which) **often reveal regularities in the close adaptation of forms to their habitat: (p. 435) forms from swift streams have a lower thermal tolerance than those from slow streams, whilst those from ponds are most resistant, in accordance with the temperature extremes expected**

in nature (p. 434). Senior White (1946) has tabulated proof of this for the stream-to-rice field fauna of the Jeypore Hills in South India, and Williamson (1935) has used changes in stream velocity as a form of biological malaria control in Malaya.

It is more than usually difficult to end this paper with the usual 'Summary and Conclusions' since the paper itself is no more than a specialized summary of a work of 645 pages. But with illustrations drawn from my own experience and studies in the cognate literature of malariology, I have endeavoured to establish the lessons for malariologists to be drawn from Huxley's treatise.

If the existence of crypto-sub-species and clines is admitted, it infers that all the vaunted methods of 'species control' require modification and improvement, and that such can only come from extensive and far more intensive studies than the most brilliant and painstaking observations in anopheline biology have so far been achieved.

The existence of races of noxious insects immune to various insecticides, and the fact that such resistance extends to poisons never normally employed in insect control foreshadows the coming of a day when the control of malaria by insecticides (including D.D.T. and gammexane) will fail the hygienist, and mosquito-borne diseases control must perforce be driven to biological methods, even when funds for chemical methods of control are available. Engineering methods will, of course, remain, but these are no more than specialized methods of biological control, achieved usually at a cost only bearable in exceptional conditions.

The need of malariology to-day is not only for more workers who can apply existing methods of investigation and control, but for investigators who will apply and extend the methods of pure zoological research to the problem of biological mosquito control.

REFERENCES.

Adisubramaniam, T. S., and Vedamanikkam, J. C. (1943). — The breeding places of *A. fluviatilis*. *J. Mal. Inst. Ind.*, **5**, p. 53.

Barber, M. A. (1921) ... ... 'Some observations and experiments on Malayan Anopheles with special reference to the transmission of malaria.' *Phil. J. S.* (B) XII, **1**, p. 1.

Boyd, M. F., and Russell, J. C. (1943). — *Am. J. Trop. Med.*, **23** (4), p. 457.

Covell, G. (1938-39) ... ... Annual report of the Malaria Institute of India for the year 1938-39.

Fennah, R. G. (1946) ... ... On the formation of genera and species in the insect fauna of the lesser antilles. *Proc. Ent. Soc.* (A), pp. 73–80.

Gater, B. A. R., and Rajamoney, P. D. (1929). — Summary of records of anopheline breeding places in Malaya. *Bull. Inst. Med. Res. F. N. S.* 2 of 1929.

Hackett, L. W. (1937) ... ... *Malaria in Europe.* Oxford Univ. Press.

Hackett, L. W., Russell, P. F., Scharff, J. W., and Senior White, R. (1939). — The present use of naturalistic measures in the control of malaria. *Q. Bull. Health Org., L. of N.*

Huff, C. G. (1931) ... ... The inheritance of natural immunity to *P. cathemarium* in 2 species of Culex. *J. Prev. Med.*, **5**, p. 249.

King, L. V. (1932) ... ... *Phil. J. S.*, **46**, p. 751.

Manson-Bahr, P. (1935) ... Warrington York, quoted in 'Manson' (10th ed.), pp. 128, 135.

MISSIROLI, A. (1947) ... ... *Riv. Parasitol.*, **8** (2–3), VI–IX.

RAJINDAR PAL (1947) ... ... *Trans. Roy. Soc. Trop. Med. Hyg.*, **40**, p. 361.

RAO, V. V., ROY, B. B., and RAO, P. J. (1942). Swarming of *sundaicus* and *subpictus*. *J. Mal. Inst. Ind.*, **4**, p. 405.

RAO, V. V., and PHILIP, M. (1947) ... *Ind. J. Mal.*, **1**, p. 37.

RIBBANDS, C. R. (1944) ... Influence of rainfall, tides and periodic fluctuations on a population of *A. melas*. *Bull. Ent. Res.*, **35**, p. 271.

ROBSON, G. C., and RICHARDS, O. W. (1936). *The variation of animals in nature.* Longmans Green, London.

ROZEBOOM, L. E. (1942) ... Sub-specific variations among neotropical Anopheles and their importance in the transmission of malaria. *Am. J. Trop. Med.*, **22**, p. 235.

SENIOR WHITE, R. (1934) ... Three years' mosquito work in Calcutta. *Bull. Ent. Res.*, **25**, p. 551.

Idem R. (1936) ... On Williamson's herbage cover method of malaria control. *Rec. Mal. Surv. Ind.*, **6**, p. 439.

Idem R. (1940) ... Studies on the adult biology of *A. culicifacies*. *J. Mal. Inst. Ind.*, **3**, p. 213.

Idem R. (1946) ... On anopheline breeding in ricefields. *Ibid.*, **6**, p. 437.

Idem R. (1947*a*) ... On the anthropophilic indices of some Indian Anopheles. *Ind. J. Mal.*, **1**, p. 111.

Idem R. (1947*b*) ... Malaria on the North Madras Coast. *Ibid.*, **1**, p. 81.

SENIOR WHITE, R., GHOSH, A. R., and RAO, V. V. (1945). On the adult biology of some Indian Anopheles with special reference to pyrethrum spraying. *J. Mal. Inst. Ind.*, **6**, p. 129.

SENIOR WHITE, R., and GHOSH, A. R. (1946). House spraying with D.D.T., further results. *Ibid.*, **6**, p. 489.

SWELLENGREBEL, N. H., and DE BUCK, A. (1938). *Malaria in the Nederlands.* Sceltema and Halkama Ltd., Amsterdam.

UNGUREANN, E., and SHUTE, P. G. (1947). The value of the wing scales as an aid to the taxonomy of adult *A. maculipennis*. *Proc. R. Ent. Soc.* (B), **16**, p. 79.

VISWANATHAN, D. K. (1946) ... Malaria transmission by *A. fluviatilis*. *J. Mal. Inst. Ind.*, **6**, p. 253.

WATSON, M. (1921) ... ... *The prevention of malaria in the F. M. S.*, 2nd Edition.

WILLCOCKS, C. (1946) ... ... *Rept. Yell. Fever Inst., Lagos*, 1945.

WILLIAMSON, K. B. (1928) ... Mosquito breeding and malaria in relation to the nitrogen cycle. *Bull. Ent. Res.*, **18**, p. 433.

Idem (1935) ... *Control of rural malaria by natural methods.* L. of N. Eastern Bureau, 1935, Singapore.

WILLIAMSON, K. B., and ZAIN, M. (1937). A presumptive Culicine host of the human malaria parasites. *Nature*, **139**, p. 714. *Trans. Roy. Soc. Trop. Med. Hyg.*, **31**, p. 3.

Indian Journal of Malariology, **2**, *1 and 2, June 1948.*

PROPHYLACTIC USE OF PALUDRINE IN A TEA ESTATE.

BY

MAJOR A. P. RAY, M.B., B.S.
(Assistant Director, Malaria Institute of India.)

[April 12, 1948.]

THE EFFICACY of the biguanidine derivative 'paludrine' (Curd, Davey and Rose, 1945) as an antimalarial therapeutic agent has been established by Adams *et al.* (1945) in the United Kingdom, Fairley (1946) in Australia and others abroad, and by Afridi *et al.* (1947), De and Datta (1947), Ghosh (1947), Parekh and Boghani (1947) and others in India.

As a prophylactic, Fairley (*loc. cit.*) in an experimental investigation with daily doses found paludrine to be superior to all other known antimalarial drugs but its value in prophylaxis against Indian strains of malaria parasites had yet to be fully established and consequently large-scale experiments both in the laboratory and in the field were initiated in different parts of India by Major-General Sir Gordon Covell, Director, Malaria Institute of India, in 1946.

Fairley had previously stated in a communication (unpublished) that a weekly prophylactic dose of 0·1 gm. leaves no margin for error but that a bi-weekly dose of 100 mg. should act as a complete causal prophylactic. The same view was held by Covell who had stated in another communication (also unpublished) that a weekly prophylactic dose of 0·1 gm. of paludrine though not completely successful reduced the incidence of malaria in endemic and hyperendemic areas, in the latter case to a somewhat lesser extent. Similar results were later reported by Viswanathan and Baily (1947).

A prophylactic of 0·2 gm. in two doses on consecutive days each week was tried by Hamilton (1947) but the results were not encouraging, and the number placed on this regime was too small for definite conclusions to be arrived at.

The present report deals with a large-scale field experiment arranged in 1947 by Lieut.-Colonel M. K. Afridi with the co-operation of Lieut.-Colonel Hay Arthur, Chief Medical Officer, Central Duars, in Dima Tea Estate (located in a

hyperendemic area) at Kalchini, Jalpaiguri District (North Bengal), and a general plan was formulated under their guidance.

Its chief objects were to determine the efficacy of paludrine as a prophylactic drug in a single weekly dose of 0·3 gm. (3 tablets) and in two doses of 0·1 gm. (1 tablet) each bi-weekly, and the effects of mass prophylaxis on a community particularly a labour force in a hyperendemic area. Additional experiments were also undertaken with chloroquine (Synonyms SN 7618 : Resochin : Aralen).

TOPOGRAPHY.

The site of Dima Tea Estate is mainly flat, though the terrain is slightly undulating in places, with a general slope towards the south.

Numerous seepages originate near the foot of the Bhutan Hills 10 to 12 miles towards the north and these are connected with runnels which in their turn join drains. These are small at first but later become main drains, some of which pass through the labour lines of the estate.

Due to the high subsoil water level particularly during the rains, the ground becomes spongy and numerous seepages appear particularly on the sides of the drains.

To the south of Dima lie the estates of Bhatkhawa and Attiabari where conditions are almost identical.

RAINFALL.

The annual rainfall averages 140 to 150 inches, of which 115 to 120 inches fall during the monsoon period (June to September). It is heavier in the surrounding hilly districts and starts there somewhat earlier, as a general rule in the beginning of June though there may be slight variation in certain years. As much as 12 to 15 inches a day and 20 to 40 inches a week have been recorded and usually there are several dry intervals of 10 to 12 days (Graph 1).

Slight showers of rain occur in April and May and are usually termed *chota barsat*, or little monsoon.

TEMPERATURE AND HUMIDITY.

The average variation of maximum and minimum temperatures during the period of the monsoon is about 20°F. and is fairly constant for individual months. The maximum temperature is in the region of 92 to 95°F. while the minimum ranges from 75 to 72°F. After October the minimum may drop to 60°F. and the maximum in winter months remains between 85 and 90°F.

The average monthly temperature during 1947 as compared to that in 1946 and the average of the preceding five years are shown in Table I.

There is very little change in the relative humidity during the year. It ranges in general from 75 to 80 per cent but occasionally rises as high as 92 per cent during July and August.

TABLE I.

Monthly mean temperature during 1942 to 1946 (April to October) and average daily temperature for the same months in 1946 and 1947.

	1942 to 1946.		1946.		1947.	
	Maximum, °F.	Minimum, °F.	Maximum, °F.	Minimum, °F.	Maximum, °F.	Minimum, °F.
April ...	90	70	90	72	92	70
May ...	93	75	92	71	95	75
June ...	95	75	95	73	96	75
July ...	90	73	92	75	90	77
August ...	92	78	93	71	90	76
September ...	89	72	88	72	88	74
October ...	88	65	89	68	85	68

LABOUR FORCE.

The labour force on Dima Estate is of approximately 2,800 strong including about 900 children, and is derived mainly from Chota Nagpur District of Bihar, and to a lesser extent from the Bhutan Hill Tract. Approximately 75 per cent live in thatched huts along a seepage belt in Dima Lines and the remainder in an area about a mile away. The force may be considered a static one as many families working in the same garden for two or three generations have settled down permanently on the land allotted to them by the tea companies. During the war, however, there was a considerable movement of labour from Bengal to Assam and Burma and *vice versa*, and many have returned to resettle in the tea districts.

New labourers are imported during the winter months to replace older ones and those returning to their villages. Their number is usually very small.

The wages are distributed to the workers through their respective headmen on a particular day of the week (Sunday) and along with the wages rations are issued at concession rates to those who work for 5 out of 6 days a week or occasionally less. In this manner the maximum attendance of the workers is ensured.

SPLEEN SURVEY.

A spleen survey carried out in April showed that, of the 418 children examined, 313 had enlarged spleens. Subsequent examinations carried out in August and October revealed spleen rates of 49·03 and 43·9 per cent respectively (Table II).

TABLE II.

Result of spleen examinations of children (2 to 10 years).

Date.	Number examined.	Number with enlarged spleen.	Spleen rate, per cent.
1947.			
April 5	418	313	74·80
August 26	416	204	49·03
October 28	191	84	43·90

PARASITE RATES.

Blood examination in the initial stages of the experiment of a cross section of 100 children and 1,549 adults later placed on prophylactic regimes showed parasite rates of 35 and 0·7 per cent respectively. Two subsequent examinations of the children (random samples) were made in July and October and of the adults in August and October (Table III).

Blood smears both thick and thin were stained with J. S. B. stain (Jaswant Singh and Bhattacharji, 1944) prepared at the estate. About 100 microscopical fields in each smear (thick and thin) were examined in every case before any opinion was recorded.

TABLE III.

Result of blood examination.

Date.	Number examined.	Number with malaria parasites.	*P. vivax.* Asexual.	*P. vivax.* Sexual.	*P. vivax.* Total.	*P. falciparum.* Asexual.	*P. falciparum.* Sexual.	*P. falciparum.* Total.	Parasite rate, per cent.
	Children (2 to 10 years).								
1947.									
April 15 ...	100	35	2	6	...	8	12	7	35·00
July 20 ...	100	17	1	...	...	5	9	2	17·00
October 28 ...	100	11	2	1	...	3	5	...	11·00
	Adults.								
April 16 ...	1,549	11	...	8	...	1	2	...	0·70
July 20 ...	1,560	5	...	1	...	1*	3	...	0·32
October 28 ...	1,465	3	...	2	...	...	1	...	0·20

* This was the only case (B-4, Table X) showing asexual forms detected in this examination among those on regime 'B'.

ENTOMOLOGICAL OBSERVATIONS.

Entomological observations were made throughout the experiment and several mosquito-catching stations were established to assess the adult densities particularly that of the known vector species (*A. minimus*). Three stations were located in Dima Tea Estate at Sukhi, Ladhoo and Nirmal Lines, the first two at the edge of the seepage belt mentioned above and two stations in Bhatkhawa Estate, one each at Hatkhola and Forest Lines; and one station in Attiabari Estate. As far as practicable, selective catches were made in Dima and Attiabari, whereas no such restrictions were placed in Bhatkhawa which is situated between Dima and Attiabari, three miles from the former and a mile and a half from the latter. The malariogenic factors in all the three places were almost identical except that D.D.T. and malariol were used in Bhatkhawa in addition to the prophylactic treatment with paludrine. No D.D.T. and/or malariol were used in Dima or Attiabari Estates, and no drug prophylaxis was instituted in the last-named station.

In Bhatkhawa Estate all the huts and quarters were sprayed with D.D.T. suspension in water on three occasions at intervals of two months. Small-scale antilarval measures were also instituted by the staff of the Chief Medical Officer of the Eastern Duars. Specimens of *A. minimus* were not encountered except on two occasions (one each time) during the mosquito catches and these too were caught after about 7 to 8 weeks after spraying with D.D.T. The total catches

including culicine mosquitoes which constituted the bulk of the catches did not on any occasion exceed eight per man-hour per hut. The species of anopheline mosquitoes caught were mainly *A. vagus*, *A. varuna*, *A. hyrcanus* and *A. fluviatilis*.

Results of the entomological observations in respect of Dima and Attiabari tea estates are shown in Tables IV and V (Graphs 1 and 2).

GRAPH 1.

Showing weekly rainfall (inches) and A. minimus *catches per man-hour per hut at Dima Tea Estate.*

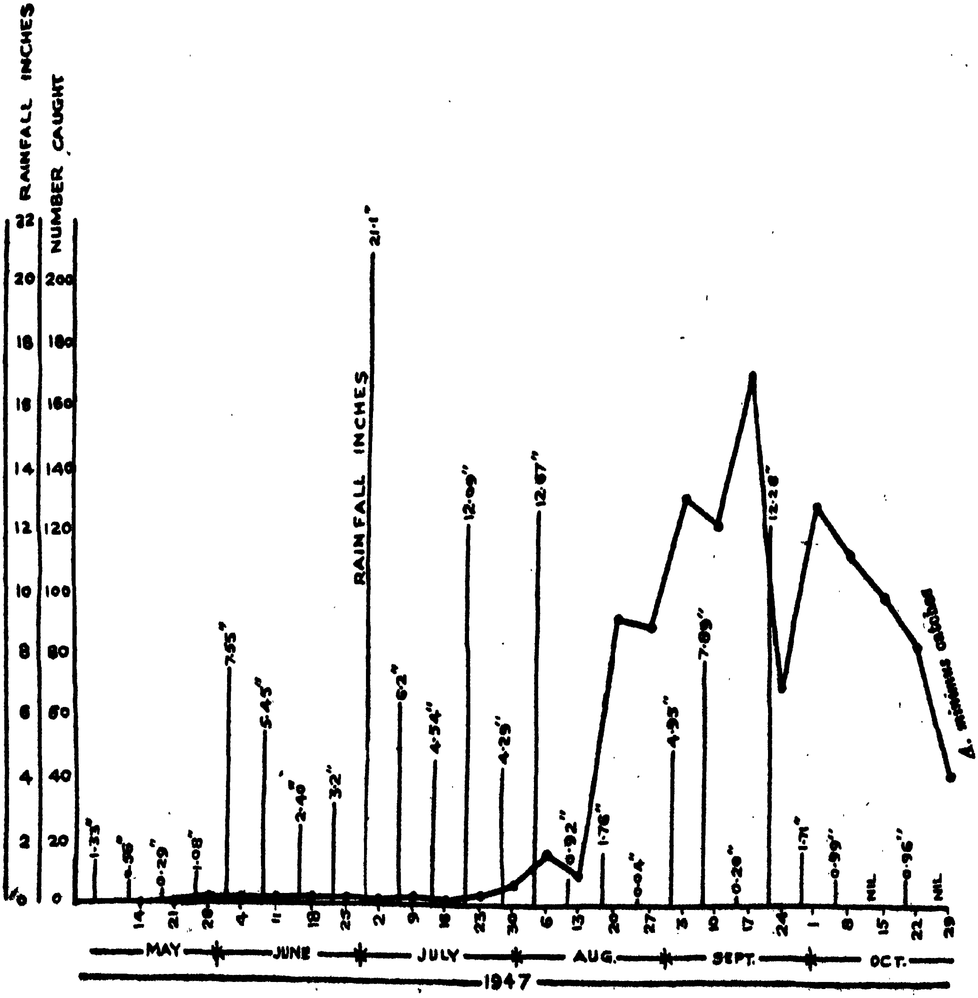


TABLE IV.

Infection rate of A. minimus.

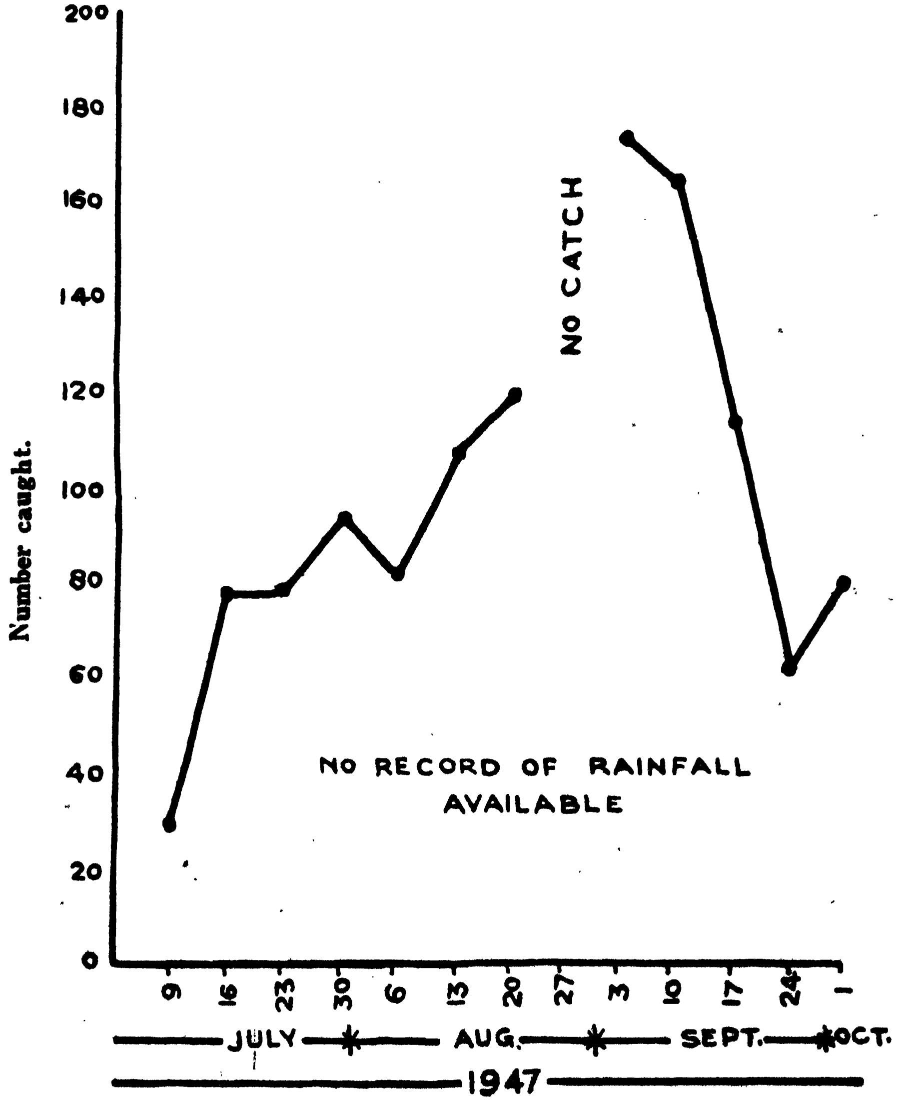
Dima Tea Estate.

During week ending			Total number caught.	Number dissected.	Number showing infection in salivary glands.	Percentage.	Average catch per man-hour per hut (*A. minimus*).
May	7	...	*Nil*	...	...	...	...
,,	14	...	*Nil*	...	...	...	...
,,	21	...	1	1	...	...	0·5
,,	28	...	6	6	...	...	1·5
June	4	...	5	5	...	...	1·0
,,	11	...	6	6	...	...	1·0
,,	18	...	8	8	1	12·5	2·0
,,	25	...	13	13	...	...	2·6
July	2	...	9	9	1	11·1	1·8
,,	9	...	12	12	...	...	2·0
,,	16	...	8	8	1	12·5	1·14
,,	23	...	21	21	...	...	3·0
,,	30	...	39	39	...	...	6·5
August	6	...	70	70	1	1·4	17·5
,,	13	...	30	30	...	...	10·0
,,	20	...	93	78	...	...	93·0
,,	27	...	180	151	1	0·66	90·0
September	3	...	265	195	1	1·51	132·5
,,	10	...	246	239	...	...	123·0
,,	17	...	514	488	5	1·02	171·3
,,	24	...	209	199	1	0·5	69·6
October	1	...	519	469	2	0·4	129·7
,,	8	...	228	189	...	...	114·0
,,	15	...	405	372	4	1·7	101·1
,,	22	...	168	159	...	...	84·1
,,	29	...	127	124	...	...	42·3

Highest infectivity rate on any individual date was recorded on September 15, when four salivary gland infections (2·05 per cent) were encountered in 195

GRAPH 2.

Average catches of A. minimus *per man-hour per hut at Attiabari Tea Estate.*



specimens. Comparatively high infection rates were noted on September 21, one positive (1·5 per cent) out of 65; on September 25, two positive (1·3 per cent) out of 145; on October 15, three positive (1·4 per cent) out of 212.

The gland infection rates of 12·5, 11·1 and 12·5 per cent recorded for the weeks ending June 18 and July 2 and 16 respectively have not been taken into consideration as the numbers of mosquitoes dissected on these occasions were very few.

TABLE V.

Infection rate of A. minimus.

Attiabari Estate.

During week ending	Total number caught.	Number dissected.	Number showing infection in salivary gland.	Percentage.	Average catch per man-hour per hut (*A. minimus*).
July 9 ...	30	30	...	...	30
„ 16 ...	78	68	1	1·46	78
„ 23 ...	79	50	...	...	79
„ 30 ...	95	80	1	0·8	95
August 6 ...	82	82	1	0·82	82
„ 13 ...	108	100	2	2·0	108
„ 20 ...	120	103	1	0·97	120
„ 27 ...	No catches were made.				
September 3 ...	175	150	1	0·66	175
„ 10 ...	165	155	...	...	165
„ 17 ...	115	97	2	2·06	115
„ 24 ...	63	55	2	3·62	63
October 1 ...	182	169	4	2·37	81

The catches in this estate were made once a week for one man-hour per hut except during the last week of September when catches were made twice and discontinued thereafter.

A comparative statement of the monthly averages in infectivity rates in the two estates is shown below:—

	May.	June.	July.	August.	September.	October.
Dima	*Nil*	3·09*	2·22*	0·86	0·62	0·44
Attiabari ...	...	...	0·87	1·40	1·09	...

* Number of mosquitoes available for dissection was comparatively small (Table IV).

PROPHYLACTIC TREATMENT.

The prophylactic treatment with paludrine and chloroquine was commenced on April 16 and continued up to October 29.

Regime A, single weekly dose of 0·3 gm. (three tablets) of paludrine.

Regime B, 0·1 gm. (one tablet) of paludrine twice weekly spaced out at 3 to 4 days' interval.

Regime C, one tablet of chloroquine (0·25 gm. base) once a week, which corresponds more or less with regime 'A', as three tablets of paludrine (0·261 gm. base) are nearly equivalent to one tablet of chloroquine.

CONDUCT OF EXPERIMENT.

In view of the administrative difficulties and loss of work usually involved in sorting out individuals under different regimes of treatment, grouping from the very start was made according to sex, particularly because the nature of the work for men and women is quite different and they do not as a rule work in the same place. Accordingly, in consultation with the management and the Chief Medical Officer of the tea estate, paludrine and chloroquine tablets were administered to the various groups at different times on particular days. All male labourers employed in the garden were placed on regime 'A', women including male and female children between the ages of 12 to 18 years working alongside the women on regime 'B', and all male labourers in the factory were placed on regime 'C'. The establishment staff were included in the last regime.

The men working in the garden under regime 'A' were given paludrine on Wednesdays early in the morning when the 'Boidar' or the man in charge of the muster book who knows the workers by name along with a few supervisory staff and water carriers of different castes was in attendance. As each man came to work and was allotted a row of the tea (mela), he was made to swallow 3 tablets of paludrine with a little water.

Those absent received the tablets on the following day either in the garden or during leaf weighment, thus ensuring a large number of regular consumers of the prophylactic drug. This process was repeated every week.

The women and children on regime 'B' were given paludrine on Tuesdays and Fridays, and as their number was greater than men, 3 to 4 groups were formed and each group was allotted a different area to work in. One group was taken up

before they started work in the mornings. By the time the first group had received the tablets, batches of 15 to 20 at a time from the remaining groups well inside the tea garden were called out by the daffadars for taking paludrine tablets and immediately afterwards resumed their work. Thus one could see waves of tea leaf pluckers some coming out and others returning to their work, all at the same time. While each one received a dose an entry was made against the name leaving no scope for wrong entries. The maximum loss of time per worker was calculated and on no occasion had a labourer to leave work for more than a few minutes. Women who did not report for duty on the appointed days were given the treatment on the following day, except when they reported sick and in that case the drug was given to them in the hospital.

In the earlier stages, distribution of chloroquine to the factory workers and establishment staff on regime 'C' was arranged on Thursdays and Fridays. At first the arrangement worked very smoothly, but at a later stage during heavy 'flush' (quick growth of leaves) when there was more work in the factory and quite a number of men were drawn from the garden for work in the factory (a normal procedure), a possible mixing up of the two regimes 'A' and 'C' was apprehended. To avoid this, names on the register of workers from the garden were indicated with blue coloured marks and those already in the factory red. Paludrine or chloroquine was administered according to the colour of the mark.

Records.—The initial entries at the time of actual drug administration first made in the 'boidar book' were transferred to the various registers maintained and all entries in respect of about 1,800 labourers during the whole period of six and a half months were made personally by the author.

Supervision.—The importance of supervision of the actual swallowing of the tablets by each person was constantly borne in mind and as such it was not entrusted to any subordinate, the author himself supervising the administration of every single tablet throughout the prophylactic treatment, whether it was in the garden, factory or in the hospital. In spite of this procedure, a certain number of labourers were irregular in attendance and some of them very irregular indeed. Besides these personal factors, the attendance was affected to a certain extent by weather conditions.

During heavy rains the normal attendance was much lower, and when the rains continued for several days particularly in the latter part of July and in August, the daily attendance progressively diminished and the number of sick reporting to hospital increased.

Other factors contributing to irregular attendance were marriages during May and early June, when groups of people were absent for days, and again in July and August during the paddy season. It was not possible to trace absentees because the majority went away from the area or worked in their own plots of land. Much confusion had of course been avoided by the initial grouping mentioned above.

Regular and irregular groups.—The average number of persons receiving prophylactic treatment under regimes 'A', 'B' and 'C' were 538, 889 and 292 respectively and of those attending regularly and irregularly have been classified below. Seventy to 80 per cent of the numbers under prophylactic treatment either received every dose or missed not more than one. The actual monthly figures of attendance are tabulated in Appendix I.

The number of persons receiving the treatment regularly throughout the whole period and who did not miss a single dose under the different regimes were :—

Regime.	Total approx.	Average strength per month.	Percentage.
'A' ...	68	538	12·6
'B' ...	49	889	5·5
'C' ...	72	292	24·6

The average monthly attendance for the period April to October is indicated in Table VI.

TABLE VI.

Number of persons who attended regularly and did not miss a single dose.	Number of persons who missed one dose only.	Number of persons who missed two doses only.		Number of persons who were very irregular.	TOTAL.
		Consecutively, alternatively or otherwise.			
		Regime 'A'.			
280	140	45	27	46	538
420					
		Regime 'C'.			
182	75	11	12	12	292
257					

Regime 'B'.

Number of persons who attended regularly and did not miss a single dose.	Number of persons who missed one dose only in a week.		Number of persons who missed both doses in a week.		Very irregular.	TOTAL.
	Once.	More than once.	Once.	More than once.		
335	213	139	62	33	107	889
548						

The European community and the clerical staff under regime 'B' took the tablets themselves and the Chief Medical Officer of the area placed children under 12 years on prophylactic treatment with paludrine under the supervision of the Assistant Medical Officer. The results relating to these two categories have not been included in this experiment. It was realized that the administration of tablets to the children might involve a great deal of irregular attendance, particularly in the case of small children whose mothers are more anxious to go to the gardens for work than wait for their children's turn for a medicinal pill.

MALARIA CASES AND STATISTICAL OBSERVATIONS.

During the season, all malaria cases reporting to Dima Hospital were examined carefully and a thorough blood examination for malaria parasites was made by the author. Cases showing asexual forms of malaria parasites with or without gametocytes were admitted to hospital. Those under prophylactic regimes 'A' and 'B' were given a single therapeutic dose of three tablets of paludrine, while a solitary case under regime 'C' received a single dose of 2 tablets of chloroquine. Four-hourly temperature charts were maintained in all cases and blood examination continued daily till parasitæmia disappeared and the patients became afebrile. On discharge the patients resumed their respective prophylactic treatments.

In previous years the majority of the cases were labelled as clinical malaria and only about 25 per cent of them were subjected to blood examination. Where a definite diagnosis could not be made, the case was recorded as pyrexia of unknown origin.

Table VII shows the total number of malaria cases including those both clinically and microscopically diagnosed and those of pyrexia of unknown origin recorded from April to October for the years 1941 to 1947. The rates per 1,000 per month from January to October for the years 1941 to 1947 in respect of all cases and pyrexias of unknown origin amongst the entire population and those for adults only for 1946 and 1947 are given in Tables VIII and IX (Graphs 3 and 4).

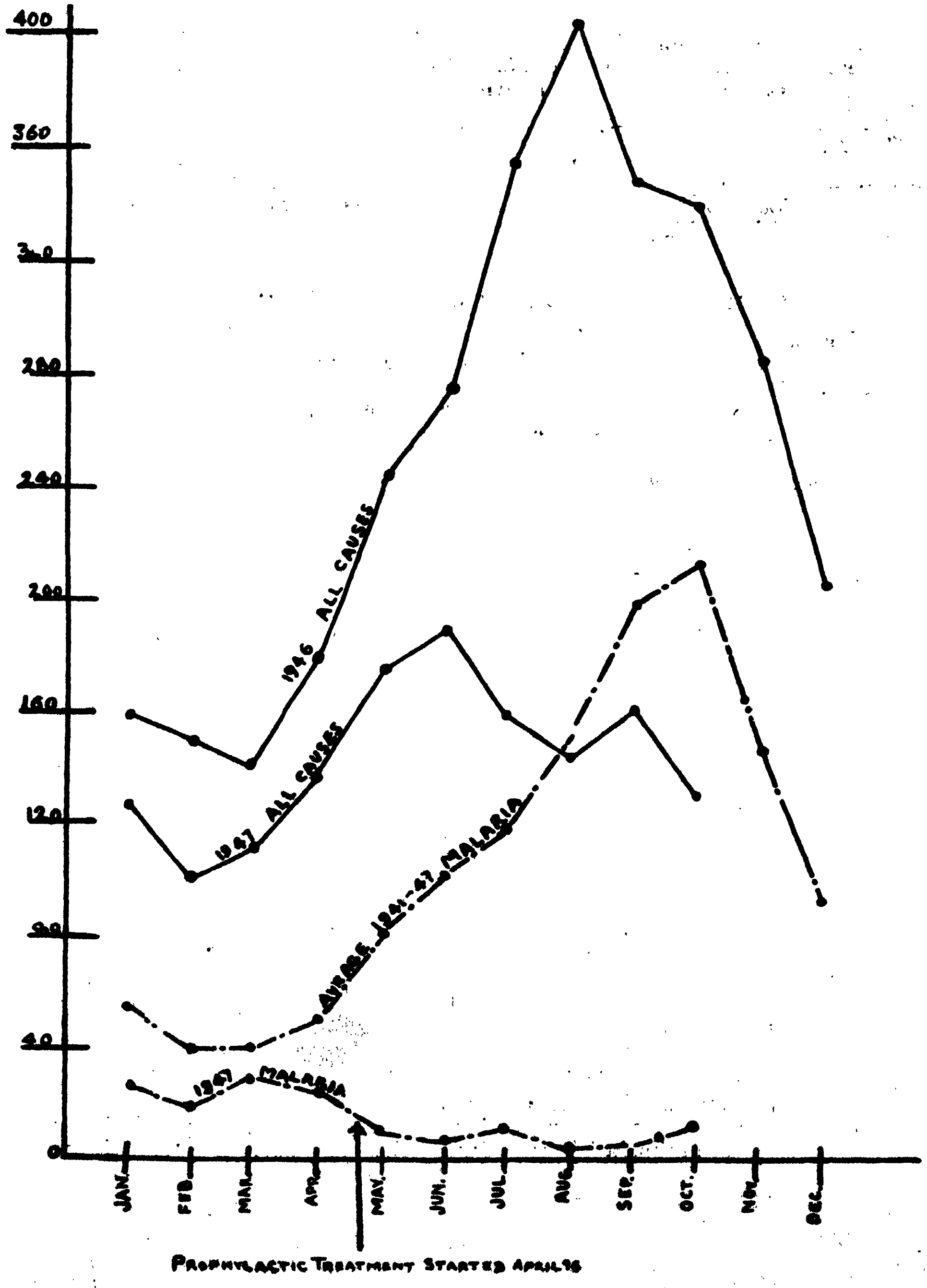
TABLE VII.

Year.	1941.	1942.	1943.	1944.	1945.	1946.	1947.
Number of cases	1,974	2,064	3,022	2,834	3,818	2,794	158

It will be seen that the incidence of malaria showed a progressive increase from 1941 onwards and was highest during the year 1945. This increase may be attributed to the constant admixture of immune and non-immune population and the acute shortage of antimalarial drugs during the war years. Mepacrine became

GRAPH 3.

Dima Tea Estate (Kalchini) shows all causes and malaria rate per 1,000 per month, average 1941–46, 1946 and 1947.



GRAPH 4.

Dima Tea Estate (Kalchini) ratio of malaria cases (adults) per thousand per month, for 1946 *and* 1947.

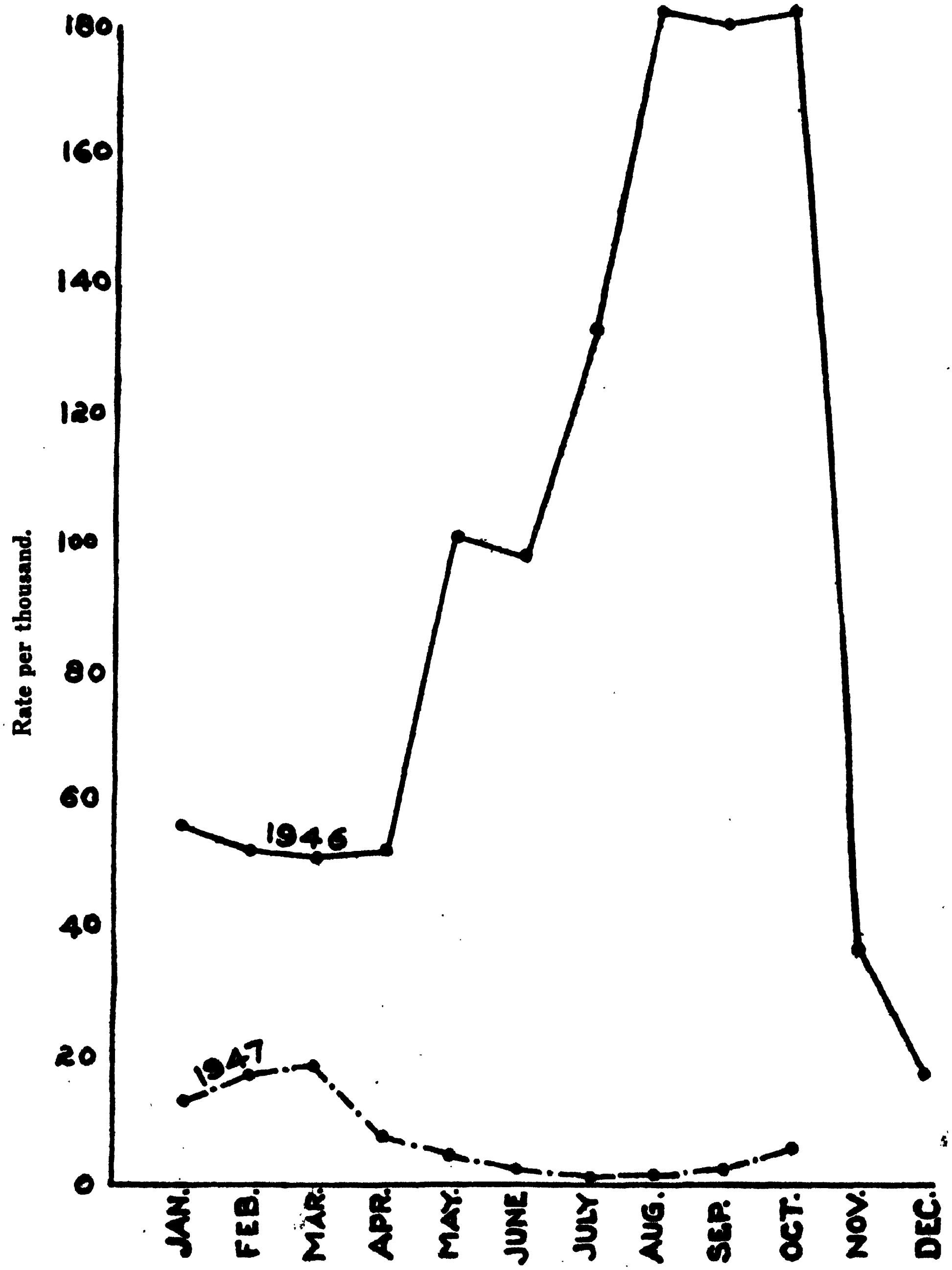


TABLE VIII.

Rate per thousand per month from January to October for the years 1941 *to* 1947 *for malaria and P.U.O. cases.*

For the entire population.

Month.	1941.	1942.	1943.	1944.	1945.	1946.	1947.
January ...	41·33	54·29	48·3	49·33	75·24	73·11	24·3
February ...	30·64	31·16	37·7	30·57	48·31	59·11	18·7
March ...	32·71	23·01	35·65	27·13	71·58	60·53	30·3
April	48·77	36·02	50·62	47·51	59·73	64·72	24·9
May	59·14	64·39	66·87	89·02	100·93	117·04	9·0
June	41·19	85·85	100·09	146·79	129·14	184·16	5·1
July	72·87	98·72	110·37	126·09	177·63	136·93	11·7
August ...	90·22	106·4	129·8	138·79	387·1	189·84	4·0
September ...	135·77	152·74	207·14	169·62	322·62	170·7	4·6
October ...	164·66	168·10	237·02	196·08	314·72	192·6	11·1

P.U.O.=Pyrexia of unknown origin.

TABLE IX.

Rate per thousand per month from January to October for the years 1941 *to* 1947 *for malaria and P.U.O. cases.*

For adults only.

Month.	Total adult strength.		Total cases.		Rate per mille per month.	
	1946.	1947.	1946.	1947.	1946.	1947.
April ...	1,700	1,750	98	12	57·6	6·8
May ...	1,750	1,900	172	9	98·28	4·37
June ...	1,682	1,900	165	2	94·8	1·05
July ...	1,680	1,800	224	3	133·3	1·66
August ...	1,670	1,805	319	*Nil*	191·01	0·00
September ...	1,670	1,805	308	4	184·4	2·2
October ...	1,650	1,800	330	13	200·00	6·66

P.U.O.=Pyrexia of unknown origin.

available from the latter part of 1946 and this by itself might explain the downward trend of fevers during the early part of 1947. Since the commencement of the prophylactic treatment with paludrine and chloroquine from April, there has been a striking reduction in the incidence of malaria fevers and P.U.O. (pyrexia of unknown origin) is noteworthy. Analysis of a combined total of 158 cases including malaria and P.U.O. cases shows that 31 cases of proved malaria out of 1,900 adults were diagnosed and 85 cases out of about 900 children were treated (Table X). Of the 31 cases, 17 (0·97 per cent) occurred among approximately 1,750 adults placed on prophylactic treatment. Fourteen (9·33 per cent) out of 150 persons were not included in this experiment although some of them were said to have received prophylactic treatment with paludrine. Of the 17 cases, seven were under regime 'A', 9 under regime 'B' and only 1 under regime 'C'. From the attendance registers it has been ascertained that 16 cases occurred in persons who had received this treatment irregularly and only 1 among 9 cases under regime 'B' was considered as a genuine breakthrough (Tables XI, XII and XIII).

TABLE X.

		Malaria cases.	Percentage.	Pyrexia of unknown origin.	Percentage.	Combined total of malaria cases and pyrexia of unknown origin.	Percentage.
Total population—monthly average from April to October.	2,800*	116	4·14	42	1·50	158	5·64
For adults	1,900	31	1·63	12	0·63	43	2·26
Number on suppressive treatment	1,750	17	0·97	1	0·06	18	1·03
Number of persons not included in this experiment although some were known to have received suppressive treatment with paludrine.	150	14	9·33	11	7·33	25	16·66
Number of children	900	85	9·44	30	3·33	115	12·77

* In nearest round figures. It has not been possible to make out such a comparison with the previous year's figures.

TABLE XI.

Cases of 'breakthrough' while on prophylactic regimes, regular or irregular (extract from registers).

Regime 'A'.

Serial number.	Name.	Age.	Sirdar's name.	April.		May.					June.			
				17	24	1	8	15	22	29	5	12	19	26
1	Somra II ...	31	Ladhoo ...	X	0 1	0	X	X	X	X	X	X	X	X
2	Hossain Ram ...	30	Dhankoo ...	X	X	X	X	X	X	X	0	X	X	0
3	Karlush ...	32	Birsha ...	X	X	X	0	X	X	X	X	X	X	X
4	Chandra Bahadur ...	34	Jetha	X	0	X	X	X	X	X	X	X	X	X
5	Bonifus	39	Birsa	...	...	...	...	...	...	...	X	X	X	X
6	Sukhoo	20	Harka Bahadur ...	...	X	0	X	X	X	X	0	X	X	X
7	Thupa	22	Ladhoo ...	X	X	X	X	X	X	X	X	X	X	X

LEGEND.

(1) Case A-1 M.T. Malaria. Overt attack on April 27, 1947.
(2) „ A-2 B.T. Infection. Overt attack on October 2, 1947.
(3) „ A-3 B.T. and M.T. Mixed Infection. Overt attack on October 9, 1947.
(4) „ A-4 B.T. Infection. Attack on October 10, 1947, December 24, 1947. M.T. Infection.
(5) „ A-5 B.T. Infection with M.T. Crescents. Attack on October 11, 1947.
(6) „ A-6 M.T. Infection. Attack on October 11, 1947.
(7) „ A-7 B.T. Infection. Attack on October 14, 1947.
X . . . . Drug taken.
0 . . . . Drug missed.

TABLE XI—*concld.*

Cases of 'breakthrough' while on prophylactic regimes, regular or irregular (extract from registers)—concld.

Regime 'A'—*concld.*

Serial number.	Name.	Age.	Sirdar's name.	July.					August.				September.				October.				
				3	10	16	23	29	7	13	20	27	3	10	17	24	2	8	15	22	29
1	Somra II ...	31	Ladhoo ...	X	X	X	X	0	X	X	X	0	X	X	0	X	X	X	X	X	X
2	Hossain Ram ...	30	Dhankoo ...	0	X	X	X	0	0	0	X	X	X	0	0	0	**2**	X	X	X	X
3	Karlush ...	32	Birsha ...	X	X	X	X	0	X	X	0	0	0	0	0	X	0	0 **3**	X	X	X
4	Chandra Bahadur	34	Jetha ...	X	X	0	X	0	X	0	0	X	X	0	0	0	0	0 **4**	X	X	X
5	Bonifus ...	39	Birsa ...	X	X	X	0	0	X	X	X	X	X	X	X	X	0	X	**5**	X	X
6	Sukhoo ...	20	Harka Bahadur	X	X	X	X	X	X	X	X	0	X	0	0	0	0	X	**6**	X	X
7	Thupa ...	22	Ladhoo ...	0	0	0	0	0	X	0	X	X	X	X	0	X	0	X	**7**	X	X

LEGEND.

(1) Case A-1 M.T. Malaria. Overt attack on April 27, 1947.
(2) „ A-2 B.T. Infection. Overt attack on October 2, 1947.
(3) „ A-3 B.T. and M.T. Mixed Infection. Overt attack on October 9, 1947.
(4) „ A-4 B.T. Infection. Attack on October 10, 1947, December 24, 1947. M.T. Infection.
(5) „ A-5 B.T. Infection with M.T. Crescents. Attack on October 11, 1947.
(6) „ A-6 M.T. Infection. Attack on October 11, 1947.
(7) „ A-7 B.T. Infection. Attack on October 14, 1947.
X . . . . Drug taken.
0 . . . . Drug missed.

DETAILS OF MALARIA CASES.

Regime 'A'.—Case A-1 (Table XI) had one dose of prophylactic paludrine on April 17, missed the second dose scheduled on April 24 and an attack occurred on April 27, i.e. 10 days after the first dose. On April 28 and 29 he was not traceable. The history of this case revealed that there had been no attack of fever during the several preceding months, the present one being due to *P. falciparum* (new infection). He was in the hospital from April 30 to May 1 and continued to receive the prophylactic dose regularly thereafter without showing any signs of recrudescence or relapse during the period of observation extending to 26 weeks. Blood examination at weekly intervals for three weeks after he had left the hospital did not reveal any parasites.

In the same table, it will be seen that cases A-2, A-3, A-6 and A-7 received the prophylactic doses very irregularly during the weeks preceding an attack in October. Cases A-2, A-4 and A-7 showed *P. vivax* infection and cases A-3 and A-5 mixed infection of *P. vivax* and *P. falciparum* and case A-6 *P. falciparum* infection only. On investigation of previous history of these cases, it was ascertained that none of them had had fever during the year 1947 and all were regarded as fresh cases.

The prophylactic treatment was terminated on October 29, and during a subsequent observation period of 3 months, only one case (A-4) developed an attack of *P. falciparum* malaria. This was regarded as a fresh attack as the previous one was due to *P. vivax*.

Case A-5 commenced the prophylactic treatment on June 5 and missed taking paludrine on three occasions, twice in July and once in the first week of October, before October 11, when he developed an attack showing mixed infection. The patient was then given therapeutic treatment and was discharged from the hospital on the fifth day after admission when he was afebrile and showed no parasites.

Regime 'B'.—In Table XII an account of 9 cases of malaria is given. Cases B-1 and B-6 developed *P. falciparum* infections after having received only one tablet of paludrine a week instead of 2 a week. This dosage did not prove effective. Cases B-2, B-4, B-7 and B-8 had missed their paludrine on frequent occasions and all had *P. falciparum* infections except case B-7 who had *P. vivax*. Case B-5 developed a *P. falciparum* attack in spite of taking paludrine regularly for several weeks prior to it and was considered to be the only case of genuine breakthrough.

Case B-9 developed *P. falciparum* infection after missing 2 doses during the last week of the prophylactic treatment in October. She had been fairly regular for about 8 weeks prior to the attack.

None of these cases developed a relapse while on prophylactic treatment after discharge from hospital and during an observation of 3 months thereafter.

Regime 'C'.—There was only one case of *P. falciparum* infection out of 292 factory workers and staff members under chloroquine treatment of one tablet weekly. This case had missed the chloroquine tablets for 2 consecutive weeks prior to the attack (Table XIII) and while in hospital he was given a single dose of 2 tablets (500 mg. chloroquine) and discharged after 5 days. He continued

TABLE XII.

Cases of 'breakthrough' while on prophylactic regimes, regular or irregular (extract from registers).

Regime 'B'.

Serial number.	Name.	Age and sex.	Sirdar's name.	April.					May.								
				16	19	23	26	30	3	7	10	14	17	21	24	28	31
1	Maino ...	35 F.	Paulush ...	O	X	X	O	1 X	X	X	X	X	X	X	X	X	X
2	Lachmin ...	24 F.	Bandhana ...	X	X	X	X	X	X	X	O	O	X	O	O	2	X
3	Sugi	20 F.	Chamra ...	X	X	X	X	X	X	X	X	X	X	X	X	O	O
4	Dilcharan ...	15 F.	Lundroo ...	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	Lakhia ...	20 F.	Neez ...	X	X	X	X	X	X	X	X	X	X	O	O	O	O
6	Sumri ...	22 F.	Ladhoo ...	...	...	...	X	X	X	X	X	O	X	O	X	X	X
7	Nimni ...	25 F.	Neez ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8	Bande ...	16 M.	Jetha ...	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9	Safia ...	20 F.	Lucas ...	...	...	...	X	X	X	X	O	X	O	O	O	O	O

LEGEND.

(1) Case B-1 M.T. Infection. Overt attack on May 2.
(2) ,, B-2 ,, ,, ,, ,, ,, May 26.
(3) ,, B-3 ,, ,, ,, ,, ,, June 14.
(4) ,, B-4 ,, ,, ,, ,, ,, July 24.
(5) ,, B-5 ,, ,, ,, ,, ,, September 9.
(6) ,, B-6 ,, ,, ,, ,, ,, September 26.
(7) ,, B-7 B.T. ,, ,, ,, ,, October 13.
(8) ,, B-8 M.T. ,, ,, ,, ,, October 15.
(9) ,, B-9 ,, ,, ,, ,, ,, October 27.
X . . . . Drug taken.
O . . . . Drug missed.

F = Female. M = Male.

TABLE XII—*contd.*

Cases of 'breakthrough' while on prophylactic regimes, regular or irregular (extract from registers)—contd.

Regime 'B'—*contd.*

Serial number.	Name.	Age and sex.	Sirdar's name.	June. 4	7	10	13	17	20	24	27	July. 1	4	8	11	15	18	22	25	28	31
1	Maino ...	35 F.	Paulush ...	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	X	0	X
2	Lachmin ...	24 F.	Bandhana ...	0	0	X	X	0	0	X	0	Left garden.									
3	Sugi ...	20 F.	Chamra ...	0	0	0	0	X	X	X	X	0	0	X	X	X	X	0	X	X	X
4	Dilcharan ...	15 F.	Lundroo ...	0	0	X	3 X	X	X	0	0	0	0	0	0	0	0	X	4	X	X
5	Lakhia ...	20 F.	Neez ...	0	0	X	X	0	X	X	0	X	X	X	X	X	X	X	X	X	X
6	Sumri ...	22 F.	Ladhoo ...	X	X	X	X	0	X	X	X	X	X	X	X	X	X	X	X	0	X
7	Nimni ...	25 F.	Neez ...	...	...	...	...	...	...	...	...	...	...	...	...	X	0	0	0	0	0
8	Bande ...	16 M.	Jetha ...	X	X	0	X	X	X	X	0	0	0	X	X	X	X	0	X	0	X
9	Safia ...	20 F.	Lucas ...	X	X	0	X	0	X	0	X	X	X	X	X	X	X	X	X	0	X

LEGEND.

(1) Case B-1 M.T. Infection. Overt attack on May 2.
(2) „ B-2 „ „ „ „ „ May 26.
(3) „ B-3 „ „ „ „ „ June 14.
(4) „ B-4 „ „ „ „ „ July 24.
(5) „ B-5 „ „ „ „ „ September 9.
(6) „ B-6 „ „ „ „ „ September 26.
(7) „ B-7 B.T. „ „ „ „ October 13.
(8) „ B-8 M.T. „ „ „ „ October 15.
(9) „ B-9 „ „ „ „ „ October 27.
X . . . . Drug taken.
0 . . . . Drug missed.

F = Female. M = Male.

TABLE XII—*contd.*

***Cases of 'breakthrough' while on prophylactic regimes, regular or irregular (extract from registers)*—contd.**

Regime 'B'—*contd.*

Serial number.	Name.	Age and sex.	Sirdar's name.	August. 5	8	11	14	19	22	26	29
1	Maino	35 F.	Paulush ...	X	X	X	X	X	X	X	X
2	Lachmin ...	24 F.	Bandhana ...			Left garden.					
3	Sugi	20 F.	Chamra ...	X	X	X	X	X	X	X	X
4	Dilcharan ...	15 M.	Lundroo ...	X	X	X	X	X	X	X	X
5	Lakhia	20 F.	Neez	X	X	X	X	X	X	X	X
6	Sumri	22 F.	Ladhoo ...	X	X	X	X	X	X	O	X
7	Nimni	25 F.	Neez	X	X	O	O	X	O	X	O
8	Bande	16 M.	Jetha	O	O	O	O	O	O	O	O
9	Safia	20 F.	Lucas	O	O	X	X	X	O	X	X

LEGEND.

(1) Case B-1 M.T. Infection. Overt attack on May 2.
(2) ,, B-2 ,, ,, ,, ,, ,, May 26.
(3) ,, B-3 ,, ,, ,, ,, ,, June 14.
(4) ,, B-4 ,, ,, ,, ,, ,, July 24.
(5) ,, B-5 ,, ,, ,, ,, ,, September 9.
(6) ,, B-6 ,, ,, ,, ,, ,, September 26.
(7) ,, B-7 B.T. ,, ,, ,, ,, October 13.
(8) ,, B-8 M.T. ,, ,, ,, ,, October 15.
(9) ,, B-9 ,, ,, ,, ,, ,, October 27.
X . . . . Drug taken.
O . . . . Drug missed.

F = Female. M = Male.

TABLE XII—*concld.*

Cases of 'breakthrough' while on prophylactic regimes, regular or irregular (extract from registers)—concld.

Regime 'B'—*concld.*

Serial number.	Name.	Age and sex.	Sirdar's name.	September.								October.								
				2	5	9	13	16	19	23	26	1	4	7	10	14	17	21	25	28
1	Maino ...	35 F.	Paulush ...	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	Lachmin ...	24 F.	Bandhana ...	—Left garden—																
3	Sugi ...	20 F.	Chamra ...	X	X	X	X	X	O	X	X	X	X	O	X	X	X	X	X	X
4	Dilcharan ...	15 M.	Lundroo ...	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	Lakhia ...	20 F.	Neez ...	X	X	**5**	X	X	X	X	O	O	O	X	X	X	O	O	X	X
6	Sumri ...	22 F.	Ladhoo ...	X	O	X	O	X	X	X	**6**	X	X	X	X	X	X	X	X	X
7	Nimni ...	25 F.	Neez ...	O	X	X	O	O	X	O	O	O	O	X	O	X	X	X	X	X
8	Bande ...	16 M.	Jetha ...	O	O	O	O	O	O	O	O	O	O	X	O	O	**8**	X	X	X
9	Safia ...	20 F.	Lucas ...	X	X	X	X	O	X	X	X	X	X	X	X	X	X	O	O	**9**

LEGEND.

(1) Case B-1 M.T. Infection. Overt attack on May 2.
(2) „ B-2 „ „ „ „ „ May 26.
(3) „ B-3 „ „ „ „ „ June 14.
(4) „ B-4 „ „ „ „ „ July 24.
(5) „ B-5 „ „ „ „ „ September 9.
(6) „ B-6 „ „ „ „ „ September 26.
(7) „ B-7 B.T. „ „ „ „ October 13.
(8) „ B-8 M.T. „ „ „ „ October 15.
(9) „ B-9 „ „ „ „ „ October 27.
X . . . . Drug taken.
O . . . . Drug missed.

F = Female. M = Male.

TABLE XIII.

Regime 'C'.

Serial number.	Name.	Age and sex.	Sirdar's name.	April.		May.					June.				
				18	25	2	9	16	23	30	6	9	16	19	26
1	Mohona ...	30 M.	Carpenter ...	X	X	X	X	X	X	X	X	X (X)	O	X (X)	X

LEGEND.

(X) Dates of drug administration were changed on several occasions to suit the convenience of the factory workers. To avoid long gaps of 10 to 12 days, drug was given earlier.

X . . . . Drug taken.
O . . . . Drug missed.

M = Male.

TABLE XIII—*concld.*

Regime 'C'—*concld.*

Serial number.	Name.	Age and sex.	Sirdar's name.	July.					August.				September.				October.				
				2	10	17	24	30	7	13	21	28	4	11	18	25	3	9	16	22	28
1	Mohona ...	30 M.	Carpenter ...	X	X	O	O (1)	X	X	X	X	X	X	X	X	X	X	X	X	X	X

LEGEND.

(1) Case C-1 M.T. Infection. Overt attack on July 24, 1947. A. N.
(X) Dates of drug administration were changed on several occasions to suit the convenience of the factory workers. To avoid long gaps of 10 to 12 days, drug was given earlier.

X . . . . Drug taken.
O . . . . Drug missed.

M = Male.

to receive the tablets regularly once a week till the end of the prophylactic treatment. There was no relapse or recurrence of symptoms during an observation period of 9 months after the attack of fever in July.

MORTALITY RATES.

Comparative figures for the total birth, death and infant mortality rates showing marked improvement are :—

Birth rate per mille per annum.		Death rate per mille per annum.		Infant mortality rate per mille per annum.	
1946.	1947.	1946.	1947.	1946.	1947.
13·80	39·3	32·77	16·60	260·4	171·05

ATTENDANCE.

The average daily attendance of the labourers in 1947 was high as compared with previous years and a statement of the percentage of daily average turnout in 1947 during the period April to October and the mean during the same period during the years 1944 to 1946 is shown in Table XIV.

Table XIV.

Percentage of daily attendance of the labourers in 1947 *and that of the mean of* 1944 *to* 1946 *during the period April to October.*

Month.	Mean—1944 to 1946, per cent.	Mean—1947, per cent.
April	76·55	82·04
May	67·45	80·75
June	66·40	80·02
July	67·01	76·83
August	69·35	76·42
September ...	67·10	74·48
October	71·74	80·27

Approximate strength of the working population—1,750.

No previous records are available to show the spleen rates, parasite rates or the infection rates of *A. minimus* but there can be little doubt regarding the hyperendemicity of this area. The spleen rate as determined at the beginning of this experiment was 74·8 per cent and this would ordinarily have shown an increase during and immediately after the malaria season but in actual fact a significant reduction to 43·9 per cent in October was recorded. The parasite rates likewise show a marked decrease from 35·0 per cent in April to 11·0 per cent in October amongst the children and from 0·7 per cent to 0·2 per cent in adults (Table III). It must be remembered that no other antimalaria or antimosquito measures were adopted in Dima Tea Estate.

The infectivity rates in *A. minimus* in Dima Estate given in Table IV show that out of a total of 2,814 specimens dissected only 18 showed sporozoites in salivary glands (0·64 per cent). In Attiabari the sporozoite rate was 1·3 per cent —15 specimens positive out of 1,134 dissected.

Records of previous dissections show an average gland infection rate of 2·7 per cent in *A. minimus*, i.e. 391 positive specimens out of 14,092 dissected during a period of 10 years (1931 to 1940) in 46 centres including 14 tea estates in Assam (Anderson and Viswanathan, 1941) and a sporozoite rate 1·4 per cent, i.e. 72 positive specimens out of 5,120 dissected during the year 1940-41 in 25 centres in Assam (Viswanathan, Das and Oommen, 1941). Midgut infections in *A. minimus* have not been included in the above or in the present series of dissections.

The sporozoite rate in Dima Estate during 1947 remained consistently lower than those recorded by Anderson, Viswanathan and others and those of the neighbouring Attiabari Estate. It may be argued that as a result of the prophylactic treatment the infectivity rate in *A. minimus* was comparatively much lower during this season when the total number of malaria cases was only a fraction of that of the previous years.

The outstanding features of the prophylactic treatment of about 550 adults on regime 'A', 300 mg. paludrine in single weekly doses, nearly 900 women and older children on regime 'B', 100 mg. paludrine twice a week, and about 300 adults on regime 'C', one tablet of chloroquine weekly, were :—

1. A marked reduction in the total sickness from all causes during the period April to October 1947. The total sickness from all causes in the entire population in the season under review was lower than the average rates for malaria alone in the previous years. There were no deaths due to malaria.

2. A striking reduction in the number of malaria cases diagnosed clinically and microscopically including pyrexia of unknown origin.

3. Not a single case occurred in individuals who had received the prophylactic treatment regularly throughout the season without missing a single dose under any of the regimes. The few cases that did develop malaria were amongst persons known to have missed the drug frequently with one exception in regime 'B' who was classified as a genuine breakthrough. Regimes 'A' and 'C' gave completely successful results and in these two courses the administration of the drug was more convenient than under regime 'B'. It is learnt that the

manufacturers will make paludrine tablets of 300 mg. each available by next year and it will be possible to administer a single tablet instead of 3 as in regime 'A'.

4. A reduction of the infant mortality rates, death rates, spleen rates, parasite and infectivity rates in the malaria-carrying anopheline mosquitoes *A. minimus*.

5. A complete absence of any toxic symptoms due to the administration of drugs.

6. A general improvement in health among the labour force as testified both by the authorities and by the labourers themselves.

7. Maximum attendance when compared to previous years.

No attempt has been made to assess the economic gains to the authorities of the tea companies and to the workers themselves.

CONCLUSIONS.

A carefully supervised field trial has been carried out, and from the results recorded it is concluded that :—

(*i*) Paludrine is an effective prophylactic and suppressive in both B.T. and M.T. malaria in a dose of 0·3 gm. weekly, or 0·1 gm. twice weekly at spaced intervals.

(*ii*) Chloroquine is equally effective in doses of 0·25 gm. of base once weekly.

(*iii*) There was no toxicity observed with either drug.

Although attendance was improved as compared with previous years, no attempt is made to assess the economic gains to the employers or the employees.

ACKNOWLEDGMENTS.

The author wishes to thank Major-General Sir Gordon Covell, C.I.E., late Director of the Malaria Institute of India, and Lieut.-Colonel M. K. Afridi, C.B.E., now Director, Malaria Institute of Pakistan, for their kind guidance in drawing up the plan; to Lieut.-Colonel Hay Arthur, O.B.E., Chief Medical Officer, Central Duars, Messrs. R. W. Bain and S. J. Young, the Manager and Assistant Manager, and to the staff of the Dima Tea Company, including Dr. S. K. Sanyal, for their most helpful co-operation in so many ways to which the success of the experiment in a large measure is attributed.

The author particularly wishes to express his gratefulness to Lieut.-Colonel Jaswant Singh, O.B.E., Director, Malaria Institute of India, for his most valuable advice at various stages of the experiment, and finally wishes to record his appreciation of the excellent field work by Messrs. Mool Chand, Krishen Dutt and Nasib Singh of the Malaria Institute of India.

REFERENCES.

Adams, A. R. D., Maegraith, B. G., King, J. D., Townsend, R. H., Davey, T. H., and Harvard, R. E. (1945). *Ann. Trop. Med. Parasit.*, **39**, pp. 225–231.

Afridi, M. K. (1947) ... *Ind. J. Mal.*, **1**, pp. 347–359.

Afridi, M. K., Ramakrishnan, S. P., Goswami, A., and Menon, M. K. (1947). *Ibid.*, **1**, pp. 221–229.

Anderson, L. A. P., and Viswanathan, D. K. (1941). *Assam Medical Research Society*, Shillong, p. 4.

Curd, F. H. S., Davey, D. G., and Rose, F. L. (1945). *Ann. Trop. Med. Parasit.*, **39**, pp. 157–164.

Idem (1945). *Ibid.*, **39**, pp. 208–216.

Davey, D. G. (1946) ... *Trans. Trop. Med. Parasit.*, **40**, pp. 171–180.

De, M. N., and Datta, P. N. (1947). *Ind. Med. Gaz.*, **82**, pp. 257–260.

Fairley, N. H. (1946) ... *Trans. Roy. Soc. Trop. Med. Hyg.*, **40**, pp. 105–162.

Ghosh, B. N. (1947) ... *Ind. J. Mal.*, **1**, pp. 369–371.

Hamilton, C. S. P. (1947) ... Juri Valley Report. 'Report of the control for the year ended 1947.'

Jaswant Singh and Bhattacharji, L. M. (1944). *Ind. Med. Gaz.*, **79**, p. 102.

Lomax, P. H. (1947) ... *Ind. J. Mal.*, **1**, pp. 389–393.

Maegraith, B. G., Adams, A. R. D., King, J. D., Townsend, R. H., Davey, T. H., and Harvard, R. E. (1945). *Ann. Trop. Med. Parasit.*, **39**, pp. 232–236.

Parekh, J. G., and Boghani, B. P. (1947). *Ind. Med. Gaz.*, **82**, pp. 253–255.

Viswanathan, D. K., and Baily, J. D. (1947). *Ind. J. Mal.*, **1**, pp. 307–318.

Viswanathan, D. K., Das, S., and Oommen, A. V. (1941). *J. Mal. Inst. Ind.*, **4**, pp. 297–306.

APPENDIX I.

Classification of regular or irregular groups under prophylactic regimes each month.

During the month	Number of persons who attended regularly and did not miss a single dose.	Number of persons who missed one dose only.	Number of persons who missed two doses only. Consecutively/Alt./otherwise.		Number of persons very irregular in attendance.	TOTAL.
Regime 'A'.						
April ...	423	116	(Prophylactic regime w.e.f. 16th.)			539
May ...	261	157	46	39	64	567
June ...	313	117	48	17	21	516
July ...	271	156	37	27	67	558
August ...	289	145	38	27	37	536
September ...	274	137	65	27	39	542
October ...	290	122	48	25	45	530
Regime 'C'.						
April ...	180	46	...	...	...	226
May ...	220	57	5	8	3	295
June ...	177	78	10	19	14	298
July ...	171	82	20	12	20	305
August ...	181	79	10	8	14	292
September ...	165	82	13	15	10	285
October ...	172	76	12	9	7	276

APPENDIX I—*concld.*

Month.	Number of persons who attended regularly and did not miss a single dose.	Number of persons who missed one dose in a week.		Number of persons who missed both doses in a week.		Number of persons very irregular in attendance.	TOTAL.
		Once.	More than once.	Once.	More than once.		
			Regime 'B'.				
April ...	626	165	7	8	*Nil*	*Nil*	816
May ...	356	241	169	38	8	128	940
June ...	479	169	54	49	30	126	907
July ...	280	222	125	93	64	131	915
August ...	315	237	174	64	38	68	896
September ...	295	199	175	67	37	86	859
October ...	330	189	180	62	40	98	899

Indian Journal of Malariology, **2**, 1 *and* 2, March/*June* 1948.

THE DISTRIBUTION OF ANOPHELINE MOSQUITOES IN INDIA, PAKISTAN, CEYLON AND BURMA : PART V* : ADDITIONAL RECORDS, 1936–47.

BY

I. M. PURI, M.SC. (Punjab), Ph.D. (Cantab.).

(*Deputy Director, Malaria Institute of India.*)

[April 15, 1948.]

THE records of the distribution of anopheline mosquitoes of India and Ceylon have already been summarized by Covell (1927, 1931)†, Barraud (1933)† and Puri (1936)† up to the end of 1935 in four separate publications.

In this paper attempt has been made to bring together, up to the end of 1947, all *new* records since the publication of the last paper in 1936. As in the previous three publications on 'Additional Records' of distribution (Covell, Barraud, Puri) only *new* records have been dealt with here. In cases where a species has already been cited in any of the previous papers in this series, as occurring in any particular locality, additional records of that species from the same place have not been included.

Since the publication of the last paper (Puri, 1936)† on this subject, various changes have taken place in the geographical alignment of some of the provinces of India and in the division of others for the creation of Pakistan. An attempt has been made to incorporate most of these changes in this paper. The Punjab, instead of being divided into 'Punjab East and North' and 'Punjab South-West', has now been divided into 'East Punjab' which remains a part of India, and 'West Punjab' which is now a part of Pakistan; Bengal has been divided into East Bengal (which now forms a part of Pakistan) and West Bengal; Chota Nagpur

* This paper may be considered as Part V of the distribution of anopheline mosquitoes in India or as the Fourth Supplement to the *Ind. Med. Res. Mem.*, No. 5.

† *Part I.* Covell, G. (1927). The distribution of anopheline mosquitoes in India and Ceylon. *Ind. Med. Res. Mem.*, No. 5.

Part II. Covell, G. (1931). The distribution of anopheline mosquitoes of India and Ceylon : Additional records (1926–1930). *Rec. Mal. Surv. Ind.*, **2**, 2, pp. 225–268.

Part III. Barraud, P. J. (1933). Additional records of the distribution of anopheline mosquitoes in India. *Rec. Mal. Surv. Ind.*, **3**, 3, pp. 507–525.

Part IV. Puri, I. M. (1936). The distribution of anopheline mosquitoes of India and Ceylon : Additional records (1931–1935). *Rec. Mal. Surv. Ind.*, **6**, 1, pp. 177–211.

has been merged into Bihar and the boundary of the province of Orissa has been extended to include Ganjam District, and a part of Vizagapatam District, the latter portion under the name of Koraput District.

A number of States are in the process of either merging into different provinces or into one another to form *new* geographical entities under different names but for the present they have been left as in the previous papers on distribution.

The species of anophelines, and the geographical divisions, sub-divisions and localities from which they have been recorded, have been given in alphabetical order. Figures preceded by the letters MB. refer to entries in the identification registers of the Malaria Institute of India, Delhi. All other figures refer to the reports and articles cited in the list of references at the end of the paper. These references have been serially numbered in continuation of those given by Puri (1936)* in Part IV of this series.

Anopheles aconitus.

ASSAM.

Goalpara Dist., Haltugaon, **213**; **Lakhimpur Dist.,** Limbuguri, **230**; **Sibsagar Dist.,** †Selenghat, **MB. 134-36,** Tocklai, **228.**

BIHAR.

Bhagalpur Dist., †Bhaptiahi, **MB. 155-40,** Saharsa, **MB. 27-41**; **Darbhanga State,** †Gangapur, **MB. 152-40,** †Madhepur-Bheja, **MB. 23-41**; **Ranchi Dist.,** Jonha, **221f**; **Singhbhum Dist.,** Dangoaposi, **224,** Gua, Kolhadi, Posoita, **223**; **Muzaffarpur Dist.,** †Muzaffarpur, **MB. 170-36.**

BOMBAY DECCAN.

Dharwar Dist., †Hubli, **MB. 10-41.**

CENTRAL PROVINCES EAST.

Bilaspur Dist., Khongsara, Belghana, **222b**; **Khairgarh State,** Bortalao, Chandsurat, Paniyajobi, **222b**; **Raigarh State,** Jamga, Himgir, **221f**; **Udaipur State,** Dharamjaygarh, **217.**

CENTRAL PROVINCES WEST.

Balaghat Dist., Arnameta, Charegaon, **222b**; **Bilaspur Dist.,** Khodri, **222b.**

---

* *Part I.* Covell, G. (1927). The distribution of anopheline mosquitoes in India and Ceylon. *Ind. Med. Res. Mem.*, No. 5.

Part II. Covell, G. (1931). The distribution of anopheline mosquitoes of India and Ceylon: Additional records (1926–1930). *Rec. Mal. Surv. Ind.*, **2**, 2, pp. 225–268.

Part III. Barraud, P. J. (1933). Additional records of the distribution of anopheline mosquitoes in India. *Rec. Mal. Surv. Ind.*, **3**, 3, pp. 507–525.

Part IV. Puri, I. M. (1936). The distribution of anopheline mosquitoes of India and Ceylon: Additional records (1931–1935). *Rec. Mal. Surv. Ind.*, **6**, 1, pp. 177–211.

† Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

CEYLON.

Mirigama, **201.**

EAST BENGAL (PAKISTAN).

Backergunge Dist., Lalmohan, **204a** ; **Chittagong Dist.,** Sitakund, **204b** ; **Dacca Dist.,** Dhamrai, **204a** ; **Faridpur Dist.,** Pangsa, **204b** ; **Jessore Dist.,** Kotchandpur, **204b** ; **Khulna Dist.,** Satkira, **204b** ; **Mymensingh Dist.,** Iswarganj, **204a,** Tangail, **204b** ; **Nadia Dist.,** Haringhata, **204a** ; **Rajshahi Dist.,** Natore, **204b** ; **Rangpur Dist.,** Palashbari, **204a** ; **Tippera Dist.,** Laksam, **204b.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194.**

MADRAS DECCAN.

Bellary Dist., Hospet, Sirigeri, Siruguppa, **215** ; **Kurnool Dist.,** Kurnool, **215.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Gudalur, Kallar, **218b** ; **Tanjore Dist.,** Pattukkottai, **219.**

MALABAR.

Malabar Dist., Chedleth, Kalpatta, *Sultan's Battery, **199.**

ORISSA.

Ganjam Dist., Balugan, Chotrapur, Gangadharpur, Kallikota, Konaka, Rambha, Sabilia, **222a,** Dubrakudi, Tolo Humma, **200** ; **Kalahandi State,** Lanjigarh Road, **221b** ; **Koraput Dist.,** Ambodala, Polypinda (Theruvali), **221c,** Bariguda, Jimidiguda, Matkabadi, Muniguda, Tikarapara and Monikol, **221b,** Donda Parti, **221e** ; **Puri Dist.,** Balugaon, Kesopur, Sana Nairi, **200.**

UNITED PROVINCES EAST.

Kanpur Dist., *Kanpur, **MB. 23-44.**

WEST BENGAL.

Birbhum Dist., Illambazar, **204a** ; **Calcutta Dist.,** Bally, **216** ; **Darjeeling Dist.,** Kalimpong, **206,** Naksalbari, **204a** ; **Hoogly Dist.,** Arambagh, **204a** ; **Jalpaiguri Dist.,** Sylee, **211** ; **Midnapur Dist.,** Chandrakona, **204b,** Egra, **204a** ; **24-Parganas Dist.,** Adigunga, **204b,** Basirhat, **204a,** Falta, **220a** ; **West Dinajpur Dist.,** Phulbari, **204b.**

Anopheles aitkeni.

ASSAM.

Goalpara Dist., Haltugaon, **213.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

BURMA UPPER.

North Arakan, **203.**

CEYLON.

Madulkelle, **201.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b.**

MALABAR.

Malabar Dist., *Kalpatta, **MB. 97-41,** Sultan's Battery, **199.**

Anopheles aitkeni var. bengalensis.

ASSAM.

Manipur State, Manipur, **209.**

MADRAS COAST NORTH.

Vizagapatam Dist., *Vizagapatam, **MB. 12-44.**

Anopheles annandalei interruptus.

CEYLON.

Koslande, Peradheniya, **201.**

MADRAS SOUTH-EAST.

Nilgiris Dist., *Coonoor, **MB. 6-41.**

Anopheles annularis.

ASSAM.

Goalpara Dist., Haltugaon, **213**; **Lakhimpur Dist.,** Limbuguri, **230**; **Sibsagar Dist.,** Tocklai, **228.**

BALUCHISTAN (PAKISTAN).

Zhob Dist., Fort Sandeman, **202.**

BIHAR.

Bhagalpur Dist., *Bhaptiahi, **MB. 155-40,** *Saharsa, **MB. 27-41**; **Darbhanga State,** Benipatti, **MB. 13-45,** Gangapur, **MB. 146-40,** Madhepur, Bheja, **MB. 23-41**; **Hazaribagh Dist.,** Patratu, Pochra, Ramgarh, Sondimra, **221f**; **Manbhum Dist.,** Chandil, **MB. 56-41,** *Dhanbad, **MB. 4-44,** Jharia, **214**; **Muzaffarpur Dist.,** *Jaintpur, **MB. 17-41,** *Muzaffarpur, **MB. 170-36,** *Patepore, **MB. 153-40**; **Patna Dist.,** *Baghmundi, Chas Thana, Masna, Nekra, **MB.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

48-37 ; **Purnea Dist.**, *Bhatotar Chakla, Bashara Kothi, **MB. 25-41**, *Ishanpur, **MB. 150-40**, *Islampur, **MB. 7-41** ; **Ranchi Dist.**, *Bandgaon, **MB. 124-41**, *Bundu, **MB. 127-41**, Jonha, **221f**, *Palkot, **MB. 54-41**, *Silli, **MB. 99-41** ; **Santal Parganas**, *Pakaur, **MB. 65-41** ; **Singhbhum Dist.**, Gua, Kolhadi, Posoita, Tangresai, **223**.

BOMBAY DECCAN.

Dharwar Dist., *Hubli, **MB. 10-41.**

CENTRAL PROVINCES EAST.

Bilaspur Dist., Belghana, Bhanwar Tonk, Khodri, Khongsara, **222b** ; **Khairgarh State**, Acholi, Baidyatola, Bortalao, Chandsurat, Dongargarh, Paniyajobi, **222b** ; **Korea State**, Chirmiri, Jhagrakhand, Manendragarh, **221f** ; **Raigarh State**, Daghora, Himgir, Jamga, **221f.**

CENTRAL PROVINCES WEST.

Balaghat Dist., Arnameta, Charegaon, Lamta, Padreganj, Sonkhar, **222b** ; **Bhandara Dist.**, Darekasa, Goberwahi, **222b.**

CEYLON.

Anuradhapura (N.W.), **201**, Horowupotana (N.E.), **197**, Tissamaharma (S.E.), **197.**

EAST BENGAL (PAKISTAN).

Backergunge Dist., Lalmohan, **204a**, Patuakhali, **204b** ; **Chittagong Dist.**, Sitakund, **204b** ; **Dacca Dist.**, Dhamrai, **204b** ; **Faridpur Dist.**, Pangsa, **204b** ; **Jessore Dist.**, Kotchandpur, **204b** ; **Khulna Dist.**, Satkhira, **204b** ; **Mymensingh Dist.**, Iswargunj, **204a**, Tangail, **204b** ; **Nadia Dist.**, Haringhata, **204a** ; **Rajshahi Dist.**, Natore, **204b** ; **Rangpur Dist.**, Palashbari **204a** ; **Tippera Dist.**, Laksam, **204b.**

EAST PUNJAB.

Gurgaon Dist., *New Bairampur, *Tingra, **MB. 121-41** ; **Kangra Dist.**, *Yol, **MB. 128-41.**

GUJARAT.

Baroda State, Sayajigunj, **MB. 72-37**, *Vadnagar, Visnagar, **MB. 44-39** ; **Kutch State**, Bhuj, Mandvi, Vijaya Vilas Palace, **195.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194** ; **Parbhani Dist.**, Parbhani, **MB. 13-41.**

HYDERABAD SOUTH.

Raichur Dist., Raichur, **MB. 18-44.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

KASHMIR AND JAMMU.

*Jammu, **MB. 10-45.**

MADRAS COAST NORTH.

Chingleput Dist., Ennore, **218a , Vizagapatam Dist.,** Waltair, **225.**

MADRAS DECCAN.

Bellary Dist., Hospet, Sirigeri, Siruguppa, **215.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, **218b ; Tanjore Dist.,** Pattukkottai, **219.**

MALABAR.

Malabar Dist., *Kalpatta, **MB. 17-42,** Sultan's Battery, **199 ; Travancore State,** Perumpazhuthoor, **207.**

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Malakand Dist., *Dargai, **MB. 110-38.**

ORISSA.

Balasore Dist., *Chandipore, **MB. 100-38,** Lakshmannath, **MB. 126-39 ; Ganjam Dist.,** Chotrapur, **222a,** Dubrakudi, **200,** Gangadharpur, Kallikota, Konaka, Rambha, Sabilia, **222a,** Tolo Humma, **200 ; Kalahandi State,** Lanjigarh Road, **208 ; Koraput Dist.,** Ambodala, **221c,** Chitikona Summit, **221a,** Donda Parti, **221e,** Jharsuguda, **221f,** Muniguda (Moinkol-Polypindia), Theruvali, **221c ; Puri Dist.,** *Bharsapur, **MB. 87-36,** *Dhanapur, **MB. 145-36,** *Darutheng-Chandka, **MB. 59-37,** Kesopur, **200,** *Pratiasapur, **MB. 130-36,** Sana Nairi, **200.**

UNITED PROVINCES EAST.

Gorakhpur Dist., *Kunraghat, **MB. 114-38.**

UNITED PROVINCES WEST.

Dehra Dun Dist., *Dehra Dun, **MB. 5-45 ; Nainital Dist.,** Bazpur, **MB. 31-39.**

WEST BENGAL.

Birbhum Dist., Illambazar, **204a ; Calcutta Dist.,** Bally, **216 ; Darjeeling Dist.,** Naksalbari, **204a,** Kalimpong, **206 ; Jalpaiguri Dist.,** *Binaguri, **MB. 13-38 ; Midnapur Dist.,** Egra, **204a,** Chandrakona, **204b ; 24-Parganas Dist.,** Adigunga, **204b,** Basirhat, **204a,** Dapa, **220b,** Falta, **220a ; West Dinajpur Dist.,** Phulbari, **204b.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

Anopheles barbirostris.

ASSAM.

Goalpara Dist., Haltugaon, **213 ; Lakhimpur Dist.,** Limbuguri, **230 ; Sibsagar Dist.,** Tocklai, **228.**

BIHAR.

Bhagalpur Dist., *Bhaptiahi, **MB. 155-40,** *Saharsa, **MB. 27-41 ; Darbhanga Dist.,** Gangapur, **MB. 146-40,** Madhepur, Bheja, **MB. 23-41 ; Manbhum Dist.,** Jharia, **214 ; Muzaffarpur Dist.,** *Jaintpur, **MB. 17-41,** *Patepore, **MB. 153-40 ; Purnea Dist.,** *Ishanpur, **MB. 150-40,** *Islampur, **MB. 7-41.**

CENTRAL PROVINCES EAST.

Udaipur State, Dharamjayagarh, **217.**

CEYLON.

Anuradhapura (N.W.), **210,** Chilaw (West), **196a,** Horowupotana (N.E.), **197,** Kottawa, **196b,** Madapata Dampe, **196b,** Mahara (S.W.), **196b,** Tissamaharama (S.E.), **197,** Welimade, **201.**

EAST BENGAL (PAKISTAN).

Backergunge Dist., Lalmohan, **204a ; Rajshahi Dist.,** Natore, **204b ; Rangpur Dist.,** Palashbari, **204a.**

GUJARAT.

Baroda State, Vadnagar, **MB. 44-39 ; Kutch State,** Bhuj, **195 ; Surat Dist.,** *Chikhali, **MB. 185-37.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194.**

KONKAN.

Santa Cruz, Vakola, **MB. 181-37.**

MADRAS COAST NORTH.

Vizagapatam Dist., Waltair, **225.**

MADRAS DECCAN.

Bellary Dist., Sirigeri, Siruguppa, **215 ; Kurnool Dist.,** Kurnool, **215.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b ; Tanjore Dist.,** Pattukkottai, **219.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

MALABAR.

Malabar Dist., Kalpatta, Sultan's Battery, **199 ; Travancore State,** Kalthuritty, **MB. 38-38,** Perumpazhuthoor, **207.**

ORISSA.

Ganjam Dist., Chatrapur, Dubrakudi, **200,** Kallikota, **222a,** Konaka, **200,** Rambha, Sabilia, **222a,** Tolo Humma, **200 ; Kalahandi State,** Lanjigarh, **208 ; Koraput Dist.,** Ambodala, **221c ; Puri Dist.,** Balugaon, Kesopur, Sana Nairi, **200,** Dhanapur, **MB. 145-36.**

WEST BENGAL.

Darjeeling Dist., Naksalbari, **204a ; Midnapur Dist.,** Chandrakona, **204b,** Egra, **204a ; 24-Parganas Dist.,** Adigunga, **204b,** Dapa, **220b,** Falta, **220a.**

Anopheles barbirostris *var.* ahomi.

ASSAM.

Manipur State, Manipur, **209 ; Sibsagar Dist.,** Selenghat, **MB. 134-36.**

Anopheles barianensis.

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Kohat Dist., *Parachinar, **MB. 17-38.**

Anopheles culicifacies.

ASSAM.

Goalpara Dist., Haltugaon, **213 ; Lakhimpur Dist.,** Limbuguri, **230 ; Sibsagar Dist.,** Tocklai, **229.**

BALUCHISTAN (PAKISTAN).

Lasbela State, Bela, **MB. 23-40.**

BIHAR.

Bhagalpur Dist., *Benipatti, **MB. 13-45,** *Bhaptiahi, **MB. 155-40,** *Saharsa, **MB. 27-41 ; Darbhanga Dist.,** *Gangapur, **MB. 146-40,** Laheria Sarai, **MB. 67-36,** *Madhepur Bheja, **MB. 23-41 ; Hazaribagh Dist.,** Nayaserai, Pochra, Patratu, Ramgarh, Sondimra, **221f ; Manbhum Dist.,** *Chandil, **MB. 56-41,** Jharia, **214 ; Muzaffarpur Dist.,** Bara Varti, **MB. 81-36,** *Jaintpur, **MB. 17-41,** *Muzaffarpur, **MB. 170-36 ; Patna Dist.,** *Baghmundi, Burra Bazar, Chas Thana, Masna, Nekra, Purdih, Saharbera, **MB. 48-37 ; Ranchi Dist.,** *Bundu, **MB. 127-41,** Jonha, **221d,** *Palkot, **MB. 54-41,** *Ranchi, **MB. 19-42,** *Silli, **MB. 99-41 ; Santal Parganas,** *Pakaur, **MB. 65-41 ; Singhbhum Dist.,** Chaibasa, **MB. 90-41,** Bara Jamda, Gua, Kolhadi, Lolda, Nalda, Posoita, Sarandha, Tangresai, **223.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

BURMA LOWER.

North Arakan Coast, **203.**

CENTRAL PROVINCES EAST.

Bilaspur Dist., Belghana, Bhanwar Tonk, Kongsara, Khodri, **221d ; Khairgarh State,** Bortalao, Dongargarh, Paniyajobi, **221d,** Acholi, Baidyatola, Chandsurat, **222b ; Korea State,** Chirmiri, Manendragarh, **221d,** Jhagrakhand, **221f ; Raigarh State,** Daghora, Himgir, Jamga, **221f ; Udaipur State,** Dharamjaygarh, **217.**

CENTRAL PROVINCES WEST.

Balaghat Dist., Arnameta, Sonkhar, **222b,** Chareagaon, Lamta, Nagarwar, Padregunj, **221d ; Bhandara Dist.,** Dareksa, Goberwahi, **221d ; Nagpur Dist.,** Khamla, **MB. 36-43.**

CEYLON.

Anuradhapura (N.W.), **210,** Chilaw, **196a,** Horowupotana (N.E.), **197,** Karande (Central), **197,** Kottawa, **196b,** Madapata, **196b,** Maharsa (S.W.), **196b,** Ridigama (Central), **197,** Tissamaharama (S.E.), **197.**

EAST BENGAL (PAKISTAN).

Backergunge Dist., Lalmohan, **204a ; Dacca Dist.,** Dhamrai, **204a ; Faridpur Dist.,** Pangsa, **204b ; Jessore Dist.,** Kotchandpur, **204b ; Mymensingh Dist.,** Iswargunj, **204a,** Tangail, **204b ; Rajshahi Dist.,** Natore, **204b ; Rangpur Dist.,** Palasbari, **204a.**

EAST PUNJAB.

Gurgaon Dist., Ballula, Gawal Pahari, **MB. 113-41,** *New Bairampur, **MB. 121-41.**

GUJARAT.

Ahmedabad Dist., Ahmedabad, **205 ; Baroda State,** *Sayajigunj, **MB. 72-37,** *Vadnagar, Visnagar, **MB. 44-39 ; Idar State,** Lusadia, **MB. 11-44 ; Kutch State,** Bhuj, Mandvi, Vijaya Vilas Palace, **195 ; Nawanagar State,** Jamnagar, **MB. 64-42 ; Panch Mahals Dist.,** Shiripur, **MB. 24-37 ; Surgana State,** Bilimoria, **MB. 5-47 ; Surat Dist.,** *Kerdi Road, Kala Amba, Vaghai (Dang State), **MB. 135-36.**

HYDERABAD NORTH.

Nizamabad Dist., *Nizamsagar, **194 ; Parbhani Dist.,** Parbhani, **MB. 13-41.**

HYDERABAD SOUTH.

Raichur Dist., Raichur, **MB. 18-44.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

KASHMIR AND JAMMU.

Jammu, **MB. 68-42.**

MADRAS COAST NORTH.

East Godavari Dist., *Cocanada, **MB. 12-37 ; Vizagapatam Dist.,** Bimlipatam, **221,** Waltair, **225.**

MADRAS DECCAN.

Bellary Dist., Siriguri, **215.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b ; Tanjore Dist.,** Pattukkottai, **219.**

MALABAR.

Malabar Dist., Chedleth, Kalpatta, Sultan's Battery, **199 ; Travancore State,** Peermade, **221d,** Perumpazhuthoor, **207.**

MYSORE STATE.

Byrapura, Gargeshwari, Yedadore, **227.**

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Bannu Dist., *Ghoriwalla, **MB. 79-36 ; D. I. Khan Dist.,** *Manzai, **MB. 147-38 ; Peshawar Dist.,** Risalpur, **MB. 43-37.**

ORISSA.

Balasore Dist., Rupsa, **221d ; Cuttack Dist.,** Dhanmandal, **221d ; Ganjam Dist.,** Chotrapur, Gangadharpur, Kallikota, Konaka, Sabilia, **222a,** Dubrakudi, Tolo Humma, **200,** Baruva, Humma, **221d ; Kalahandi State,** Kakbhata, Lanjigarh Road, **221b,** Kesinga, **221d ; Koraput Dist.,** Ambodala, Bariguda, Chitikona Summit, Jimidiguda, Matkabadi, Monikol, Tikarpara (Muniguda), **221b,** Donda, **221e,** Jharsuguda, **221f,** Polypinda, **221c,** Theruvali, **221a ; Puri Dist.,** Khurda Road, Malatipatpur, **221d,** Balugaon, Kesopur, **222a,** Sana Nairi, **200.**

RAJPUTANA WEST.

Jodhpur State, Jodhpur, **MB. 9-46.**

UNITED PROVINCES EAST.

Gorakhpur Dist., Gorakhpur, **MB. 160-36.**

UNITED PROVINCES WEST.

Malhura Dist., Brindaban, **221d.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

WEST BENGAL.

Birbhum Dist., Illambazar, **204a**; **Darjeeling Dist.**, Kalimpong, **206**, Naksalbari, **204a**; **Hoogly Dist.**, Arambagh, **204a**; **Howrah Dist.**, Santragachi, **221d**; **Midnapur Dist.**, Chandrakona, **204b**, Egra, **204a**, Midnapur, **MB. 123-38**; **24-Parganas Dist.**, Adigunga, **204b**, Falta, **220a**; **West Dinajpur Dist.**, Phulbari, **204a**.

Anopheles culiciformis.

KONKAN.

North Kanara Dist., *Sirsi, **MB. 44-42.**

Anopheles dthali.

BALUCHISTAN (PAKISTAN).

Zhob Dist., Fort Sandeman, **202.**

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Swat Territory, *Chakdara, **MB. 55-36**; **Kohat Dist.**, Thal, **MB. 89-41.**

Anopheles fluviatilis.

ASSAM.

Goalpara Dist., Haltugaon, **213.**

BALUCHISTAN (PAKISTAN).

Las Bela State, Bela, **MB. 23-40.**

BIHAR.

Bhagalpur Dist., *Bhaptiahi, **155-40**; **Darbhanga State**, *Madhepur-Bheja, **MB. 23-41**; **Manbhum Dist.**, *Dhanbad, **MB. 165-38**, Jharia, **214**; **Muzaffarpur Dist.**, *Jaintpur, **MB. 17-41**, *Muzaffarpur, **MB. 1-41**; **Patna Dist.**, *Purdih, **MB. 48-37**; **Ranchi Dist.**, *Bandgaon, **MB. 124-41**, *Bundu, **MB. 130-41**, *Palkot, **MB. 61-41**, *Ranchi, **MB. 19-41**, Silli, **MB. 115-41**; **Singhbhum Dist.**, Bara Jamda, Gua, Kolhadi, Lolda, Nalda, Posoita, Sarandha, Tangresai, **223.**

BOMBAY DECCAN.

Ahmadnagar Dist., Ahmadnagar, **MB. 95-37**; **Dharwar Dist.**, Hubli, **MB. 10-41.**

CENTRAL PROVINCES (EAST).

Bilaspur Dist., Belghana, Bhanwar Tonk, Khodri, Khogsara, **222b**; **Khairgarh State**, Acholi, Baidyatola, Bortalao, Chandsurat, Dongargarh, Paniyajobi, **222b**; **Udaipur State**, Dharamjaygarh, **217.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

CENTRAL PROVINCES WEST.

Balaghat Dist., Arnameta, Chargaon, Lamta, Padreganj, Sonkhar, **222b ; Bhandara Dist.,** Darekasa, Goberwahi, **222b.**

CEYLON.

Anuradhapura, **210,** Chilwa, **196a,** Horowupotana (N.E.), **197,** Madapata, Dempe, **196b,** Mahara (S.W.), **196b,** Ridigama (Central), **197,** Tissamaharama (S.E.), **197.**

EAST PUNJAB.

Kangra Dist., *Yol, **MB. 117-41.**

GUJARAT.

Kutch State, Mandvi, **195.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194 ; Parbhani Dist.,** *Parbhani, **MB. 13-41.**

HYDERABAD SOUTH.

Raichur Dist., *Raichur, **MB. 25-44.**

KASHMIR AND JAMMU.

Jammu, **MB. 26-43.**

MADRAS DECCAN.

Bellary Dist., Sirigeri, **215.**

MADRAS COAST NORTH.

Vizagapatam Dist., Waltair, **225.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Gudalur, Kallar, **218b.**

MALABAR.

Malabar Dist., Chedleth, Kalpatta, Sultan's Battery, **199 ; Travancore State,** Perumpazhuthoor, **207.**

MYSORE STATE.

Byrapura, Gargeshwari, Yedadore, **227.**

NEPAL.

West Terai, *Belauri, **MB. 202-37.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Bannu Dist., Ghoriwala, **MB. 79-36.**

ORISSA.

Ganjam Dist., Balugaon, **200,** Rambha, **222a,** Sabilia, **200 ; Kalahandi State,** Kakbhata, Lanjigarh, **221b ; Koraput Dist.,** Ambodala, **221b,** Chitikona Summit, **221a,** Donda, Porlupalem, **221e,** Theruvali, **221a,** Bariguda, Jimidiguda, Mathabadi, Monikol, Tikarapara (Muniguda), **221b.**

RAJPUTANA EAST.

Ajmer-Merwara Province, Ajmer, **MB. 16-36.**

UNITED PROVINCES WEST.

Nainital Dist., Alapur, *Bazpur, Chakarpur, Mazra Lala, Mazra Prabhu, Mundia Kalan, **MB. 14-39.**

WEST BENGAL.

Darjeeling Dist., Kalimpong, **206,** Naksalbari, **204a.**

Anopheles gigas.

ASSAM.

Manipur State, Manipur, **209.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b.**

Anopheles gigas bailyi.

ASSAM.

Manipur State, Manipur, **209.**

Anopheles gigas refutans.

CEYLON.

Nuwara Eliya, **201.**

Anopheles gigas simlensis.

ASSAM.

Goalpara Dist., Haltugaon, 213 ; **Manipur State,** Manipur, **209 ; Sibsagar Dist.,** *Selenghat, **MB. 134-36.**

EAST PUNJAB.

Kangra Dist., *Yol, **MB. 10-43.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

KASHMIR AND JAMMU.

*Jammu, **MB. 10-45.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b.**

UNITED PROVINCES WEST.

Nainital Dist., *Bazpur, **MB. 19-39 ; Pilibhit Dist.,** *Banbasa, **MB. 6-43.**

Anopheles hyrcanus.

ASSAM.

Goalpara Dist., Haltugaon, **213 ; Lakhimpur Dist.,** Limbuguri, **230 ; Manipur State,** Manipur, **209 ; Sibsagar Dist.,** Tocklai, **228.**

BIHAR.

Bhagalpur Dist., *Bhaptiahi, **MB. 163-40,** *Saharsa, **MB. 27-41 ; Darbhanga State,** Gangapur, **MB. 159-40 ; Manbhum Dist.,** *Chandil, **MB. 71-41,** *Dhanbad, **MB. 165-38,** Jharia, **214 ; Santal Parganas,** *Pakur, **MB. 72-41 ; Muzaffarpur Dist.,** *Muzaffarpur, **MB. 8-35,** *Patepore, **MB. 158-40 ; Purnea Dist.,** Bhatotar Chakla, Bashara Kothi, **MB. 25-41,** *Ishanpur, **MB. 150-40,** *Islampur, **MB. 7-41 ; Ranchi Dist.,** *Bandgaon, **MB. 124-41,** Bundu, **130-41,** Silli, **MB. 103-41.**

CENTRAL PROVINCES EAST.

Bilaspur Dist., Bilaspur, **MB. 15-45 ; Udaipur State,** Dharamjaygarh, **217.**

CEYLON.

Akuressa, Welimade, **201,** Anuradhapura, **210,** Chilaw, **196a,** Horowupotana (N.E.), **197,** Kottawa, **196b,** Madapata, Dampe, **196b,** Mahara (S.W.), **196b,** Ridigama (Central), **197,** Tissamaharama (S.E.), **197.**

EAST BENGAL (PAKISTAN).

Chittagong Dist., Sitakund, **204b ; Dacca Dist.,** Dhamrai, **204a ; Faridpur Dist.,** Pangsa, **204b ; Jessore Dist.,** Kotchandpur, **204b ; Mymensingh Dist.,** Ishwarganj, **204a ; Nadia Dist.,** Haringhata, **204a ; Rangpur Dist.,** Palashbari, **204a ; Tippera Dist.,** Laksam, **204b.**

GUJARAT.

Baroda State, Sayajiganj, **MB. 72-37.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

HYDERABAD SOUTH.

Atraf-i-Balda Dist., Secunderabad, **MB. 130-38 ; Raichur Dist.,** Raichur, **MB. 25-44.**

MADRAS DECCAN.

Bellary Dist., Hospet, Sirigeri, Siruguppa, **215 ; Kurnool Dist.,** Kurnool, **215.**

MADRAS COAST NORTH.

Chingleput Dist., Ennore, **218a ; Vizagapatam Dist.,** Waltair, **225.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b ; Tanjore Dist.,** Pattukkottai, **219.**

MALABAR.

Malabar Dist., Kalpatta, Sultan's Battery, **199 ; Travancore State,** Perumpazhuthoor, **207.**

NEPAL.

*Khatmandu, **MB. 118-36.**

ORISSA.

Balasore Dist., *Lakshmannath, **MB. 126-39 ; Ganjam Dist.,** Chatrapur, Dubrakudi, Kallikota, Konoka, **200,** Polypinda, **221c,** Sabilia, Tolo Humma, **200 ; Kalahandi State,** Lanjigarh Road, **208 ; Koraput Dist.,** Ambodala, **221c,** Dondaparti, **221e ; Puri Dist.,** Balugaon, **200,** *Bharasapur (Pipli P. O.), **MB. 87-36,** *Dhanapur, **MB. 145-36,** Kesopur, **200,** *Pratiasapur (Pipli P. O.), **MB. 130-36,** Sana Nairi, **200.**

UNITED PROVINCES EAST.

Allahabad Dist., Allahabad, **MB. 17-40 ; Lucknow Dist.,** Lucknow, **MB. 87-39.**

WEST BENGAL.

Birbhum Dist., Illambazar, **204a ; Calcutta,** Bally, **216 ; West Dinajpur Dist.,** Phulbari, **204b ; Midnapur Dist.,** Chandrakona, **204b,** Egra, **204a ; 24-Parganas,** Adigunga, **204b,** Basirhat, **204a,** Dapa, **220b,** Falta, **220a.**

Anopheles hyrcanus sinensis.

ASSAM.

Manipur State, Manipur, **209.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

NEPAL.

Khatmandu, **MB. 175-36.**

Anopheles insulæflorum.

ASSAM.

Sibsagar Dist., Tocklai, **229.**

CEYLON.

Kitulgala, **201.**

MALABAR.

Malabar Dist., Sultan's Battery, **199.**

Anopheles jamesi.

BIHAR.

Singhbhum Dist., Kolhadi, **224.**

CENTRAL PROVINCES EAST.

Bilaspur Dist., Belghana, Khongsara, **222b**; **Khairgarh State,** Acholi, Baidyatola, Bortalao, Chandsurat, Dongargarh, Paniyajobi, **222b**; **Raigarh State,** Himgir, Jamga, **221f.**

CENTRAL PROVINCES WEST.

Balaghat Dist., Arnameta, Charegaon, Lamta, Padreganj, Sonkhar, **222b**; **Bhandara Dist.,** *Darekasa, **MB. 144-36,** Goberwahi, **222b**; **Hoshangabad Dist.,** *Pachmarhi, **MB. 8-45.**

CEYLON.

Anuradhapura, **210,** Chilaw, **196a,** Horowupatana (N.E.), **197,** Kottawa, **196b,** Madapata, Dampe, **196b,** Mahara (S.W.), **196b,** Rambukkana, **201,** Ridigama (Central), **197,** Tissamaharama (S.E.), **197.**

EAST BENGAL (PAKISTAN).

Chittagong Dist., Sitakund, **204b.**

GUJARAT.

Surat Dist., *Ahwa (Dang State), **MB. 8-46.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

MADRAS COAST NORTH.

Vizagapatam Dist., Waltair, **225.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Gudalur, Kallar, **218b ; Tanjore Dist.,** Pattukkottai, **219.**

MALABAR.

Malabar Dist., *Kalpatta, **MB. 111-41,** Sultan's Battery, **199 ; Travancore State,** *Kalthuritty, **MB. 38-38,** Perumpazhuthoor, **207.**

ORISSA.

Ganjam Dist., Chatrapur, Kallikota, **200,** Rambha, Sabilia, **222a ; Koraput Dist.,** Ambodala, **221c,** Matkabadi, **221b,** Theruvali, **221a ; Puri Dist.,** Kesopur, Sana Nairi, **200.**

WEST BENGAL.

Darjeeling Dist., Naksalbari, **204a.**

Anopheles jeyporiensis.

BIHAR.

Manbhum Dist., Jharia, **214 ; Hazaribagh Dist.,** Patratu, Pochra, Ramgarh, Sondimra, **221f ; Ranchi Dist.,** *Bundu, Jonha, **MB. 132-41,** Ranchi, **MB. 19-42 ; Patna Dist.,** *Chas Thana, Jhalda (Masina), **MB. 48-37 ; Singhbhum Dist.,** Bara Jamda, Gua, Kolhadi, Lolda, Nalda, Posoita, Tangresai, **223.**

CENTRAL PROVINCES EAST.

Khairgarh State, Bortalao, Chandsurat, Dongargarh, Paniyajobi, **222b ; Korea State,** Chirmiri, Manendragarh, **221f ; Raigarh State,** Daghora, Himgir, Jamga, **221f ; Udaipur State,** Dharamjaygarh, **217.**

CENTRAL PROVINCES WEST.

Balaghat Dist., Arnameta, Charegaon, Lamta, Padreganj, Sonkhar, **222b ; Bhandara Dist.,** Darekasa, Goberwahi, **222b ; Bilaspur Dist.,** Belghana, Bhanwar Tonk, Khongsara, Khodri, **222b ; Hoshangabad Dist.,** Pachmarhi, **MB. 11-45.**

EAST BENGAL (PAKISTAN).

Chittagong Dist., Sitakund, **204b.**

GUJARAT.

Surat Dist., *Ahwa (Dang State), **MB. 8-46.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

KONKAN.

***Bombay City, MB. 9-41.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b.**

MALABAR.

Malabar Dist., Chedleth, Kalpatta, *Sultan's Battery, **199 ; Travancore State,** Perumpazhuthoor, **207.**

ORISSA.

Ganjam Dist., Kallikota, Rambha, **222a,** Theruvali, **221a ; Koraput Dist.,** Ambodala, **221b,** Bariguda, **221b,** Chitikona Summit, **221a,** Jimidiguda, Matkabadi, Muniguda, **221b,** Monikol, Polypinda, **221c,** Tikarapara, **221b ; Kalahandi State,** Kakbhata, Lanjigarh Road, **221b.**

RAJPUTANA EAST.

Ajmer-Merwara Province, *Ajmer, **MB. 6-36.**

UNITED PROVINCES WEST.

Nainital Dist., Bazpur, **MB. 19-39.**

WEST BENGAL.

Darjeeling Dist., Naksalbari, **204a.**

Anopheles jeyporiensis candidiensis.

ASSAM.

Manipur State, Manipur, **209.**

MALABAR.

Travancore State, Perumpazhuthoor, **207.**

UNITED PROVINCES WEST.

Nainital Dist., *Bazpur, **MB. 19-39.**

Anopheles karwari.

BIHAR.

Ranchi Dist., Jonha, **221f.**

CENTRAL PROVINCES WEST.

Balaghat Dist., Arnameta, Lamta, **222b ; Hoshangabad Dist.,** Pachmarhi, **MB. 7-45.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

CEYLON.

Kottawa, **196b,** Madapata, Dampe, **196b,** Wattapota (Ratnapura), **201.**

MADRAS COAST NORTH.

Chingleput Dist., Ennore, **218a.**

MADRAS DECCAN.

Bellary Dist., Hospet, Sirigeri, Siruguppa, **215 ; Kurnool Dist.,** Kurnool, **215.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Gudalur, Kallar, **218b.**

MALABAR.

Malabar Dist., *Kalpatta, Sultan's Battery, **199 ; Travancore State,** Kalthuritty, **MB. 38-38,** Perumpazhuthoor, **207.**

ORISSA.

Koraput Dist., Ambodala, **221c,** Rambha, **222a.**

WEST BENGAL.

Darjeeling Dist., Kalimpong, **206,** Naksalbari, **204a.**

Anopheles kochi.

ASSAM.

Goalpara Dist., Haltugaon, **213 ; Lakhimpur Dist.,** Limbuguri, **230 ; Sibsagar Dist.,** Tocklai, **228.**

BURMA LOWER.

North Arakan Coast, **203.**

EAST BENGAL (PAKISTAN).

Chittagong Dist., Sitakund, **204b.**

WEST BENGAL.

Darjeeling Dist., Naksalbari, **204a.**

Anopheles leucosphyrus.

ASSAM.

Goalpara Dist., Haltugaon, **213 ; Lakhimpur Dist.,** Digboi, **198.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

CEYLON.

Madulkelle, **201.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b.**

MALABAR.

Malabar Dist., *Kalpatta, Sultan's Battery, **199 ; Travancore State,** Kalthuritty, **MB. 38-38.**

WEST BENGAL.

Darjeeling Dist., Naksalbari, **204a.**

Anopheles lindesayi.

ASSAM.

Manipur State, Manipur. **209.**

EAST PUNJAB.

Kangra Dist., *Yol, **MB. 10-43.**

KASHMIR AND JAMMU.

Jammu, **MB. 10-45.**

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Hazara Dist., *Abbottabad, **MB. 61-39.**

Anopheles lindesayi nilgiricus.

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b.**

Anopheles maculatus.

ASSAM.

Goalpara Dist., Haltugaon, **213 ; Lakhimpur Dist.,** Limbuguri, **230 ; Manipur State,** Manipur, **209.**

BALUCHISTAN (PAKISTAN).

Zhob Dist., Fort Sandeman, **202.**

BIHAR.

Ranchi Dist., *Palkot, **MB. 79-41 ; Singhbhum Dist.,** Kolhadi, **224.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

BURMA LOWER.

North Arakan Coast, **203.**

BURMA UPPER.

Shan States, *Loilem, **MB. 135-41.**

CENTRAL PROVINCES EAST.

Bilaspur Dist., Belghana, Khodri, Khongsara, **222b** ; **Korea State,** Chirmiri, Manendragarh, **221f** ; **Raigarh State,** Himgir, Jamga, **221f.**

CENTRAL PROVINCES WEST.

Bhandara Dist., Goberwahi, **222b.**

CEYLON.

Karande, Ridigama (Central), **197,** Ratnapura, **201.**

EAST PUNJAB.

Kangra Dist., *Yol, **MB. 40-42.**

KASHMIR AND JAMMU.

*Gulmarg, **MB. 88-38,** *Jammu, **MB. 68-42.**

MADRAS COAST NORTH.

Vizagapatam Dist., Waltair, **225.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b** ; **Salem Dist.,** *Harur, **MB. 44-43** ; **Tanjore Dist.,** *Pattukkottai, **MB. 105-40.**

MALABAR.

Malabar Dist., Kalpatta, *Sultan's Battery, **199** ; **Travancore State,** *Kalthuritty, **MB. 38-38.**

ORISSA.

Ganjam Dist., Rambha, **222a** ; **Kalahandi State,** Kakbhata, Lanjigarh, **221b** ; **Koraput Dist.,** Ambodala, **221b,** Chitikona Summit, **221a,** Dondaparti, **221e,** Muniguda, Polypinda, Monikol, **221c,** Theruvali, **221a,** Tikarapara, **221b** ; **Puri Dist.,** Balugaon, **200.**

UNITED PROVINCES WEST.

Nainital Dist., *Bazpur, **MB. 19-39,** *Ranikhet, **MB. 87-39.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

WEST BENGAL.

Darjeeling Dist., Kalimpong, **206,** Naksalbari, **204a.**

Anopheles majidi.

MADRAS SOUTH-EAST.

Nilgiris Dist., Gudalur, **218b.**

MALABAR.

Malabar Dist., *Kalpatta, Sultan's Battery, **199.**

ORISSA.

Koraput Dist., Ambodala, **221c.**

UNITED PROVINCES WEST.

Nainital Dist., *Bazpur, **MB. 81-39.**

WEST BENGAL.

Jalpaiguri Dist., *Binaguri, **MB. 13-36.**

Anopheles minimus.

ASSAM.

Goalpara Dist., Haltugaon, **213**; **Lakhimpur Dist.,** Digboi, **198,** Limbuguri, **230**; **Sibsagar Dist.,** Tocklai, **228.**

BIHAR.

Bhagalpur Dist., *Bhaptiahi, **MB. 155-40**; **Muzaffarpur Dist.,** *Muzaffarpur, **MB. 5-37**; **Ranchi Dist.,** Jonha, **221f**; **Singhbhum Dist.,** Bara Jamda, Gua, Kolhadi, Lolda, Nalda, Posoita, Sarandha, Tangresai, **223.**

BURMA LOWER.

North Arakan (Coast), **203.**

CENTRAL PROVINCES EAST.

Raigarh State, Himgir, Jamga, **221f.**

CENTRAL PROVINCES WEST.

Balaghat Dist., Rupzar, **222b.**

MADRAS COAST NORTH.

Vizagapatam Dist., Waltair, **225.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

ORISSA.

Kalahandi State, Kakbhata, Lanjigarh Road, **221b** ; **Koraput Dist.,** Ambodala, Bariguda, **221b,** Dondaparti, **221e,** Jimidiguda, Matkabadi, Muniguda (Monikol, Tikarapara), **221b,** Polypinda, **221c,** Porlupalem, **221e,** Theruvali, **221a** ; **Puri Dist.,** *Dhanapur, **MB. 145-36.**

UNITED PROVINCES WEST.

Nainital Dist., *Bazpur, **MB. 143-38,** Ranikhet, **MB. 87-39.**

WEST BENGAL.

Darjeeling Dist., Kalimpong, Karmatar, **206,** Naksalbari, **204a.**

Anopheles moghulensis.

BIHAR.

Manbhum Dist., *Chandil, **MB. 98-41.**

CENTRAL PROVINCES WEST.

Nagpur Dist., *Kamptee, **MB. 7-46.**

GUJARAT.

Surat Dist., *Ahwa (Dang State), **MB. 14-46.**

MADRAS DECCAN.

Bellary Dist., Hospet, Sirigeri, Siruguppa, **215** ; **Kurnool Dist.,** Kurnool, **215.**

Anopheles multicolor.

BALUCHISTAN (PAKISTAN).

Zhob Dist., Fort Sandeman, **202.**

SIND (PAKISTAN).

***Karachi, MB. 11-36.**

Anopheles pallidus.

ASSAM.

Lakhimpur Dist., Limbuguri, **230** ; **Manipur State,** Manipur, **209.**

BIHAR.

Bhagalpur Dist., *Bhaptiahi, **MB. 155-40,** *Saharsa, **MB. 27-41** ; **Darbhanga State,** *Benipatti, **MB. 13-45,** *Gangapur, **MB. 146-40,** *Madhepur-Bheja, **MB. 23-41** ; **Hazaribagh Dist.,** Nayaserai, Patratu, Pochra, Rambagh, Sondimra, **221f** ; **Manbhum Dist.,** Chandil, **MB. 96-41,** *Dhanbad, **MB. 22-39,** Jharia, **214** ;

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

Muzaffarpur Dist., *Jaintpur, **MB. 17-41,** Patepur, **MB. 153-40 ; Patna Dist.,** Bara Bazar, *Masna, Nekra, Purdih, **MB. 48-37 ; Purnea Dist.,** *Bashara Kothi, *Bhatotar Chakla, **MB. 25-41,** *Ishanpur, **MB. 150-40,** *Islampur, **MB. 7-41 ; Ranchi Dist.,** *Bundgaon, **MB. 124-41,** Bundu, **MB. 127-41,** Jonha, **221f,** Palkot, **MB. 61-41,** *Ranchi, **MB. 19-42,** *Silli, **MB. 99-41 ; Santal Parganas,** *Pakaur, **MB. 65-41 ; Singhbhum Dist.,** *Chaibasa, **MB. 90-41,** Dangoaposi, **224,** Gua, Kolhadi, Lolda, Posoita, Tangresai, **223.**

CENTRAL PROVINCES EAST.

Bilaspur Dist., Belghana, Bhanwar Tonk, Khodri, Khongsara, **222b ; Khairgarh State,** Acholi, Baidyatola, Bortalao, Chandsurat, Dongargarh, Paniyajobi, **222b ; Korea State,** Chirmiri, Jhagrakhand, Mahendragarh, **221f ; Raigarh State,** Daghora, Himgir, Jamga, **221f ; Udaipur State,** Dharamjaygarh, **217.**

CENTRAL PROVINCES WEST.

Balaghat Dist., Arnameta, Charegaon, Lamta, Padreganj, Sonkhar, **222b ; Bhandara Dist.,** Darekasa, Goberwahi, **222b.**

CEYLON.

Anuradhapura, **201,** Chilaw, **196a,** Mahara (S.W.), **196b.**

EAST BENGAL (PAKISTAN).

Chittagong Dist., Sitakund, **204b ; Jessore Dist.,** Kotchandpur, **204b ; Khulna Dist.,** Satkira, **204b ; Nadia Dist.,** Haringhata, **204a ; Rajshahi Dist.,** Natore, **204b ; Rangpur Dist.,** Palashbari, **204a ; Tippera Dist.,** Laksam, **204b.**

EAST PUNJAB.

Gurgaon Dist., *Ghata, **MB. 113-41,** New Bairampur, **MB. 121-41,** *Sailani, **MB. 112-41.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194.**

HYDERABAD SOUTH.

Parbhani Dist., *Parbhani, **MB. 106-41.**

MADRAS COAST NORTH.

Vizagapatam Dist., Waltair, **225.**

MADRAS DECCAN.

Bellary Dist., Sirigeri, Siruguppa, **215.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Gudalur, **218b ; Tanjore Dist.,** Pattukkottai, **219.**

MALABAR.

Malabar Dist., *Sultan's Battery, **199.**

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Kohat Dist., *Thal, **MB. 46-42.**

ORISSA.

Balasore Dist., *Lakshmannath, **MB. 126-39 ; Ganjam Dist.,** Balugaon, Chatrapur, Dubrakudi, **200,** Gangadharpur, Konaka, Kallikota, Rambha, Sabilia, Tolo Humma, **222c ; Kalahandi State,** Kakbhata, Lanjigarh Road, **221b ; Koraput Dist.,** Ambodala, Bariguda, **221b,** Chitikona, **221c,** Dondaparti, **221e,** Jharsuguda, **221f,** Matkabadi, **221b,** Muniguda (Monikol, Polypinda), **221c ; Puri Dist.,** *Bharasapur (Pipli P. O.), **MB. 87-36,** *Darutheng-Chandka, **MB. 59-37,** Sana Nairi, **200.**

UNITED PROVINCES EAST.

Kanpur Dist., Kanpur, **MB. 23-44.**

UNITED PROVINCES WEST.

Nainital Dist., Bazpur, **MB. 31-39.**

WEST BENGAL.

Birbhum Dist., Illambazar, **204a ; Calcutta Dist.,** Bally, **216 ; Hoogly Dist.,** Arambagh, **204a ; Midnapur Dist.,** Chandrakona, **204b,** Egra, **204a ; 24-Parganas,** Adigunga, **204b,** Basirhat, **204a,** Falta, **220a.**

Anopheles philippinensis.

ASSAM.

Goalpara Dist., Haltugaon, **213 ; Lakhimpur Dist.,** Digboi, **198,** Limbuguri, **230 ; Manipur State,** Manipur, **209 ; Sibsagar Dist.,** Tocklai, **228.**

BIHAR.

Purnea Dist., *Ishanpur, **MB. 150-40,** *Islampur, **MB. 7-41 ; Singhbhum Dist.,** Dangoaposi, Kolhadi, **224.**

EAST BENGAL (PAKISTAN).

Chittagong Dist., Sitakund, **204b ; Dacca Dist.,** Dhamrai, **204a ; Faridpur Dist.,** Pangsa, **204b ; Jessore Dist.,** Kotchandpur, **204b ; Khulna Dist.,** Satkhira, **204b ; Mymensingh Dist.,** Iswarganj, **204a,** Tangail, **204b ; Nadia Dist.,** Harin-

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

ghata, **204a** ; **Rajshahi Dist.,** Natore, **204b** ; **Rangpur Dist.,** Palashbari, **204a** ; **Tippera Dist.,** Laksam, **204b.**

HYDERABAD SOUTH.

Raichur Dist., *Raichur, **MB. 25-44.**

MALABAR.

Malabar Dist., *Kalpatta, **MB. 118-41.**

ORISSA.

Balasore Dist., *Lakshmannath, **MB. 126-39** ; **Ganjam Dist.,** Rambha, **222a** ; **Koraput Dist.,** Chitikona Summit, **221a.**

WEST BENGAL.

Birbhum Dist., Illambazar, **204a** ; **Calcutta Dist.,** Bally, **216** ; **Darjeeling Dist.,** Naksalbari, **204a** ; **Hoogly Dist.,** Arambagh, **204a** ; **Midnapur Dist.,** Chandrakona, **204b,** Egra, **204a** ; **24-Parganas Dist.,** Adigunga, **204b,** Basirhat, **204a,** Falta, **220a,** Gaurkhara, Malkapur, Paikpara, Sitola, Srikanda, **204c** ; **West Dinajpur Dist.,** Phulbari, **204b.**

Anopheles pulcherrimus.

BALUCHISTAN (PAKISTAN).

Zhob Dist., Fort Sandeman, **202.**

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Bannu Dist., Ghoriwalla, **MB. 79-36** ; **D. I. Khan,** Wana, **80-41.**

RAJPUTANA WEST.

Jodhpur State, *Jodhpur, **MB. 15-46.**

UNITED PROVINCES WEST.

Nainital Dist., *Bazpur, **MB. 19-39.**

Anopheles ramsayi.

BIHAR.

Bhagalpur Dist., Bhaptiahi, **MB. 155-40** ; **Darbhanga State,** Benipatti, **MB. 13-45** ; **Santal Parganas,** *Pakaur, **MB. 72-41.**

CENTRAL PROVINCES EAST.

Raigarh State, Himgir, **221f** ; **Udaipur State,** Dharamjaygarh, **217.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

CEYLON.

Chilaw, **201.**

EAST BENGAL.

Chittagong Dist., Sitakund, **204b ; Faridpur Dist.,** Pangsa, **204b ; Jessore Dist.,** Kotchandpur, **204b ; Khulna Dist.,** Satkira, **204b ; Mymensingh Dist.,** Iswarganj, **204a ; Nadia Dist.,** Haringhata, **204a ; Rajshahi Dist.,** Natore, **204b ; Tippera Dist.,** Laksam, **204b.**

MADRAS COAST NORTH.

Vizagapatam Dist., Waltair, **225.**

ORISSA.

Ganjam Dist., Balugaon, Chatrapur, Dubrakudi, **200,** Gangadharpur, Kalikota, Rambha, Sabilia, **222a,** Tolo Humma, **200 ; Koraput Dist.,** Chitikona Summit, **221a,** Dondaparti, **221e ; Puri Dist.,** *Bharasapur (Pipli P. O.), **MB. 87-36,** *Dhanapur (Pipli P. O.), **MB. 145-36,** *Pratiasapur (Pipli P. O.) **MB. 130-36,** Kesopur, Sana Nairi, **200.**

WEST BENGAL.

Birbhum Dist., Illambazar, **204a ; Calcutta Dist.,** Bally, **216 ; Darjeeling Dist.,** Naksalbari, **204a ; Hoogly Dist.,** Arambagh, **204a ; Midnapur Dist.,** Chandrakona, **204b,** Egra, **204a ; 24-Parganas,** Adigunga, **204b,** Basirhat, **204a,** Dapa, **220b,** Falta, **220a ; West Dinajpur Dist.,** Phulbari, **204b.**

Anopheles sergenti.

BALUCHISTAN (PAKISTAN).

Zhob Dist., Fort Sandeman, **202.**

Anopheles splendidus.

ASSAM.

Garo Hills, *Tura, **MB. 66-36.**

BALUCHISTAN (PAKISTAN).

Quetta, Loralai, **MB. 50-40.**

BIHAR.

Bhagalpur Dist., Bhaptiahi, **MB. 155-40 ; Hazaribagh Dist.,** Ramgarh, **221f ; Manbhum Dist.,** Chandil, **MB. 56-41,** Jharia, **214 ; Muzaffarpur Dist.,** *Jaintpur, **MB. 41-41 ; Ranchi Dist.,** *Bandgaon, **MB. 124-41,** *Bhagalpur, **MB. 155-40,** Bundu, **MB. 134-41,** Jonha, **221f,** *Palkot, **MB. 54-41,** Ranchi,

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

MB. 19-42 ; Singhbhum Dist., Gua, **223,** Jamshedpur, **MB. 2-45,** Kolhadi, Posoita, Sarandha, Tangresai, **223.**

CENTRAL PROVINCES EAST.

Bilaspur Dist., Belghata, Bhanwar Tonk, Khongsara, Khodri, **222b ; Khairgarh State,** Dongargarh, Paniyajobi, **222b ; Korea State,** Chirmiri, Jhagrakhand, Mahendragarh, **221f ; Raigarh State,** Daghora, Himgir, Jamga, **221f.**

CENTRAL PROVINCES WEST.

Balaghat Dist., Arnameta, Charegaon, Lamta, Padreganj, **222b ; Bhandara Dist.,** Darekasa, Goberwahi, **222b.**

EAST PUNJAB.

Kangra Dist., *Yol, **MB. 117-41.**

GUJARAT.

Surat Dist., *Ahwa (Dang State), **MB. 12-46.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194 ; Parbhani Dist.,** *Parbhani, **MB. 13-41.**

KASHMIR AND JAMMU.

*Jammu, **MB. 10-45.**

MADRAS COAST NORTH.

Vizagapatam Dist., Waltair, **225.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b.**

MALABAR.

Malabar Dist., Kalpatta, *Sultan's Battery, **199.**

NEPAL.

*Khatmandu, **MB. 106-36.**

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Bannu Dist., Ghoriwalla, **MB. 79-36 ; Peshawar Dist.,** Dargai, **MB. 45-40.**

ORISSA.

Kalahandi State, Lanjigarh Road, **221b ; Koraput Dist.,** Ambodala, Bariguda, Jimidiguda, **221b,** Chitikona, Jharsuguda, **221f,** Matkabadi, Muniguda (Monikol, Tikarapara), **221b,** Theruvali, **221a,** Polypinda, **221c,** Rambha, **222a.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

UNITED PROVINCES EAST.

Faizabad Dist., Faizabad, **MB. 50-42.**

WEST BENGAL.

Darjeeling Dist., Kalimpong, **206,** Naksalbari, **204a ; Jalpaiguri Dist.,** *Binaguri, **MB. 13-36.**

Anopheles stephensi.

ASSAM.

Goalpara Dist., Haltugaon, **213.**

BALUCHISTAN (PAKISTAN).

Las Bela State, *Bela, **MB. 23-40.**

BIHAR.

Bhagalpur Dist., *Bhaptiahi, **MB. 155-40 ; Darbhanga State,** Gangapur, **MB. 146-40 ; Manbhum Dist.,** Chandil, **MB. 71-41,** Jharia, **214 ; Santal Parganas,** *Pakaur, **MB. 65-41.**

BOMBAY DECCAN.

Dharwar Dist., *Dharwar, **MB. 13-42.**

CENTRAL PROVINCES EAST.

Khairgarh State, Chandsurat, **222b.**

CENTRAL PROVINCES WEST.

Nagpur Dist., *Khamla, **MB. 1-45.**

EAST PUNJAB.

Kangra Dist., *Yol, **MB. 40-42.**

GUJARAT.

Ahmedabad Dist., *Ahmedabad, **205 ; Baroda State,** *Sayajiganj, **MB. 72-37,** Vadnagar, Visnagar, **MB. 44-39 ; Kutch State,** Bhuj, Mandvi, Vijaya Vilas Palace, **195 ; Nawanagar State,** *Jamnagar, **MB. 68-42.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194 ; Prabhani Dist.,** Prabhani, **MB. 13-41.**

KASHMIR AND JAMMU.

Jammu, **MB. 10-45.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

MADRAS COAST NORTH.

Vizagapatam Dist., Waltair, **225 ; Chingleput Dist.,** Ennore, **218a.**

MADRAS DECCAN.

Bellary Dist., Sirigeri, Siruguppa, **215 ; Kurnool Dist.,** Kurnool, **215.**

MADRAS SOUTH-EAST.

Tanjore Dist., Pattukkottai, **219.**

MALABAR.

Cochin State, Ernakulam, **MB. 15-43.**

MYSORE STATE.

Byrapura, Gargeshwari, Yedadore, **227.**

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Bannu Dist., Ghoriwalla, **MB. 79-36 ; D. I. Khan,** *Manzai, **MB. 147-38,** *Wana, **MB. 80-41 ; Swat Territory,** Chakdra, **MB. 55-36.**

ORISSA.

Ganjam Dist., *Chatrapur, **MB. 161-39 ; Koraput Dist.,** Jharsuguda, **221f.**

UNITED PROVINCES WEST.

Nainital Dist., *Bazpur, **MB. 19-39.**

WEST PUNJAB (PAKISTAN).

Rawalpindi Dist., *Chaklala, **MB. 68-41.**

Anopheles subpictus.

ASSAM.

Goalpara Dist., Haltugaon, **213 ; Lakhimpur Dist.,** Limbuguri, **230.**

BIHAR.

Bhagalpur Dist., Bhaptiahi, **MB. 155-40,** Saharsa, **MB. 27-41 ; Darbhanga State,** Benipatti, **MB. 13-45,** Gangapur, **MB. 146-40,** Madhepur, **MB. 23-41 ; Manbhum Dist.,** Chandil, **MB. 56-41,** *Dhanbad, **MB. 165-38,** Jharia, **214 ; Muzaffarpur Dist.,** *Bara Varti, **MB. 81-36,** *Jaintpur, **MB. 17-41,** Patepore, **MB. 153-40 ; Purnea Dist.,** *Bashara Kothi, Bhatotar, Chakla, **MB. 25-41,** *Islampur, **MB. 7-41 ; Ranchi Dist.,** *Badgaon, **MB. 124-41,** Palkot, **MB. 54-41,** *Ranchi, **MB. 19-42 ; Santal Parganas,** Pakaur, **MB. 65-41 ; Singhbhum Dist.,** *Chaibasa, **MB. 90-41.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

BOMBAY DECCAN.

Dharwar Dist., Dharwar, **MB. 13-42.**

CENTRAL PROVINCES EAST.

Udaipur State, Dharamjaygarh, **217.**

CENTRAL PROVINCES WEST.

Nagpur Dist., Khamla, **MB. 36-43.**

CEYLON.

Anuradhapura (N.W.), **210,** Chilaw, **196a,** Horowuptana (N.E.), **197,** Karande (Central), **197,** Kottawa, **196b,** Madapata Dampe, **196b,** Mahara (S.W.), **196b,** Mirigama, **201,** Puttalam, **201,** Ridigama (Central), **197,** Tissamharama (S.E.), **197.**

EAST BENGAL (PAKISTAN).

Backergunge Dist., Lalmohan, **204a ; Rangpur Dist.,** Palashbari, **204a.**

EAST PUNJAB.

Gurgaon Dist., Baikhera, Sailani, Satlaka, **MB. 112-41,** Ballula, Ghata, Gwal Pahari, **MB. 113-41,** New Bairampur, Old Bairampur, Tingra, **MB. 121-41 ; Kangra Dist.,** Yol, **MB. 31-42.**

GUJARAT.

Ahmedabad Dist., Ahmedabad, **MB. 76-39 ; Baroda State,** *Sayajigunj, **MB. 72-37,** Vadnagar, Visnagar, **MB. 44-39 ; Kutch State,** Bhuj, Mandvi, Vijaya Vilas Palace, **195 ; Nawanagar State,** Jamnagar, **MB. 64-42 ; Surat Dist.,** *Kerdi Road, Kola Amba, Vaghai (Dang State), **MB. 135-36.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194 ; Parbhani Dist.,** Parbhani, **MB. 13-41.**

HYDERABAD SOUTH.

Raichur Dist., Raichur, **MB. 18-44.**

KASHMIR AND JAMMU.

Jammu, **MB. 26-43.**

MADRAS COAST NORTH.

East Godavari Dist., Cocanada, **MB. 10-37 ; Chingleput Dist.,** Ennore, **218a ; Vizagapatam Dist.,** Waltair, **225.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

MADRAS DECCAN.

Bellary Dist., Sirigeri, **215.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b ; Tanjore Dist.,** Pattukkottai, **219.**

MALABAR.

Cochin State, Ernakulam, **MB. 15-43 ; Malabar Dist.,** Chedleth, Kalpatta, Sultan's Battery, **199 ; Rameshwaram** (Island), **MB. 108-37.**

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Peshawar Dist., Risalpur, **MB. 37-43.**

ORISSA.

Balasore Dist., *Balaramgari, *Chandipore, *Santal Basti, **MB. 94-37 ; Ganjam Dist.,** Chatrapur, Dubrakondi, Kallikota, Konaka, Sibilia, Tolo Humma, **200 ; Kalahandi State,** Lanjigarh Road, **208 ; Koraput Dist.,** Ambodala, Chitikona, **221c,** Dondaparti, **221e,** Polypinda, **221c,** Theruvali, **221a ; Puri Dist.,** Balugaon, **200,** Bharasapur (Pipli P. O.), **MB. 87-36,** *Darutheng-Chandka, **MB. 59-37,** Kesopur, **200,** *Pratiasapara, **MB. 130-36,** Sana Nairi, **200.**

RAJPUTANA EAST.

Jodhpur State, Jodhpur, **MB. 9-46.**

UNITED PROVINCES EAST.

Etah Dist., Etah, **MB. 87-39 ; Gorakhpur Dist.,** Kunraghat, **MB. 114-38.**

UNITED PROVINCES WEST.

Nainital Dist., *Bazpur, **MB. 19-39.**

WEST BENGAL.

Birbhum Dist., Illambazar, **204a ; Calcutta Dist.,** Bally, **216 ; Darjeeling Dist.,** Kalimpong, **206,** Naksalbari, **204a ; Midnapur Dist.,** Egra, **204a ; 24-Parganas Dist.,** Basirhat, **204a,** Dapa, **220b,** Ichapur-Nawabgunj, **MB. 120-36.**

Anopheles sundaicus.

EAST BENGAL (PAKISTAN).

Backergunge Dist., Lalmohan, **204a,** Patuakhali, **204b ; Chittagong Dist.,** Sitakund, **204b.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

MADRAS COAST NORTH.

Vizagapatam Dist., Chicacole, Devanaaltada, Gollagundi (Uppalam Group), Iskalapalam, Mulapet, Narasannapeta, **226,** Vizagapatam, **MB. 8-40.**

ORISSA.

Cuttack Dist., Dhanmandal, **222a** ; **Ganjam Dist.,** Bhadapalli, Boropali, Bavanapada, Chikli, **200,** Chatrapur, **222a,** Dubrakudi, **200,** Gandapalli, Gangadharpur, Kallikota, *Konaka, Naupada, *Rambha, Sibilia, **222a,** Tolo Humma, **200** ; **Puri Dist.,** Balugaon, Binjhala, **200,** Bodomohuri, **MB. 4-45,** Digitpara, *Jagannath, **MB. 34-37,** Kesopur, Matapockra, **200,** Puri, **212,** Sana Nairi, **200.**

WEST BENGAL.

Calcutta Dist., Bally, **216** ; **24-Parganas,** Dapa, **220b.**

Anopheles superpictus.

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Bannu Dist., *Ghoriwalla, **MB. 79-36** ; **Kohat Dist.,** Thal, **MB. 89-47.**

Anopheles tessellatus.

BIHAR.

Manbhum Dist., *Dhanbad, **MB. 4-43** ; **Hazaribagh Dist.,** Patratu, Sondimra, **221f** ; **Ranchi Dist.,** *Bundu, **MB. 134-41,** Jonha, **221f,** *Silli, **MB. 115-41** ; **Singhbhum Dist.,** Kolhadi, **224.**

BURMA LOWER.

North Arakan Coast, **203.**

CENTRAL PROVINCES EAST.

Bilaspur Dist., Khongsara, **222b** ; **Khairgarh State,** Acholi, Baidyatola, Dongargarh, **222b** ; **Raigarh State,** Himgir, Jamga, **221f.**

CENTRAL PROVINCES WEST.

Balaghat Dist., Lamta, **222b** ; **Bhandara Dist.,** Darekasa, **222b** ; **Hoshangabad Dist.,** *Pachmarhi, **MB. 8-45.**

CEYLON.

Akuressa, **201,** Chilaw (West), **196a,** Karande (Central), **197,** Madola (Ratnapura), **201,** Tissamaharama (S.E.), **197.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

EAST BENGAL (PAKISTAN).

Backergunge Dist., Lalmohan, **204b ; Chittagong Dist.,** Sitakund, **204b ; Faridpur Dist.,** Pangsa, **204b ; Mymensingh Dist.,** Iswargunge, **204a,** Tangail, **204b.**

GUJARAT.

Surat Dist., *Ahwa (Dang State), **MB. 6-46.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194.**

HYDERABAD SOUTH.

Raichur Dist., *Raichur, **MB. 18-44.**

MADRAS COAST NORTH.

Chingleput Dist., Ennore, **218a ; Vizagapatam Dist.,** Waltair, **225.**

MADRAS DECCAN.

Bellary Dist., Hospet, Sirigeri, Siruguppa, **215 ; Kurnool Dist.,** Kurnool, **215.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Kallar, **218b ; Tanjore Dist.,** *Pattukkottai, **219.**

MALABAR.

Kalpatta, Sultan's Battery, **199 ; Travancore State,** *Kalthuritty, **MB. 38-38,** Perumpazhuthoor, **207.**

ORISSA.

Ganjam Dist., Ambodala, Monikol, **221c,** Balugaon, Gangadharpur, Kallikota, Konoka, Rambha, Sibilia, **222a,** Chatrapur, Dubrakudi, Tolo Humma, **200 ; Kalahandi State,** Lanjigarh Road, **208 ; Koraput Dist.,** Dondaparti, **221e,** Jharsuguda, **221f,** Polypinda, **221c ; Puri Dist.,** Balugaon, Kesopur, Sana Nairi, **200.**

UNITED PROVINCES EAST.

Faizabad Dist., *Faizabad, **MB. 46-43 ; Lucknow Dist.,** *Lucknow, **MB. 45-42 ; Shahjahanpur Dist.,** *Shahjahanpur, **MB. 45-43.**

WEST BENGAL.

Darjeeling Dist., Naksalbari, **204a ; Jalpaiguri Dist.,** *Binaguri, **MB. 186-37,** Sylee, **211 ; 24-Parganas Dist.,** Falta, **220a ; West Dinajpur Dist.,** Phulbari, **204b.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

Anopheles theobaldi.

BIHAR.

Ranchi Dist., Jonha, **221f,** *Palkot, **MB. 83-41,** Ranchi, **MB. 19-42; Singhbhum Dist.,** Kolhadi, **224,** Tangresai, **223.**

BOMBAY DECCAN.

East Khandesh Dist., *Bhusawal, **MB. 21-41.**

CENTRAL PROVINCES EAST.

Bilaspur Dist., Bhanwar Tonk, Belghana, Khodri, Khongsara, **222b; Khairgarh State,** Bortalao, **222b; Korea State,** Chirmiri, Jhagrakhand, Mahendragarh, **221f; Raigarh State,** Himgir, **221f.**

CENTRAL PROVINCES WEST.

Bhandara Dist., Darekasa, Goberwahi, **222b.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194; Parbhani Dist.,** *Parbhani, **MB. 13-41.**

MADRAS COAST NORTH.

Vizagapatam Dist., Waltair, **225.**

MADRAS DECCAN.

Bellary Dist., Hospet, Sirigeri, Siruguppa, **215; Kurnool Dist.,** Kurnool, **215.**

ORISSA.

Ganjam Dist., Konaka, Rambha, **222a; Kalahandi State,** Kakbhata, Lanjigarh Road, **221b; Koraput Dist.,** Ambodala, Bariguda, Jimidiguda, Matkabadi, **221b,** Polypinda, **221c,** Theruvali, **221a.**

Anopheles turkhudi.

BALUCHISTAN (PAKISTAN).

Zhob Dist., Fort Sandeman, **202.**

BOMBAY DECCAN.

Ahmadnagar Dist., *Ahmadnagar, **MB. 95-37; East Khandesh Dist.,** *Bhusawal, **MB. 34-41.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

CENTRAL PROVINCES EAST.

Raipur Dist., Dongargarh, **MB. 6-42.**

CENTRAL PROVINCES WEST.

Bhandara Dist., Goberwahi, **MB. 6-42**; **Hoshangabad Dist.**, Pachmarhi, **MB. 8-45.**

GUJARAT.

Ahmedabad Dist., Ahmedabad, **MB. 13-40**; **Kutch State**, Bhuj, Mandvi, **195.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194.**

HYDERABAD SOUTH.

Raichur Dist., Raichur, **MB. 25-44.**

MADRAS DECCAN.

Bellary Dist., Hospet, Sirigeri, Siruguppa, **215.**

NORTH-WEST FRONTIER PROVINCE (PAKISTAN).

Bannu Dist., *Ghoriwalla, **MB. 79-36**; **D. I. Khan Dist.**, Manzai, **MB. 147-38**, Wana, **MB. 80-41**; **Hazara Dist.**, Abbottabad, **MB. 62-39**; **Kohat Dist.**, *Parachinar, **MB. 17-38**, *Thal, **MB. 133-37**; **Peshawar Dist.**, Dargai, **MB. 45-40.**

UNITED PROVINCES EAST.

Lucknow Dist., Lucknow, **MB. 23-43.**

Anopheles umbrosus.

ASSAM.

Goalpara Dist., Haltugaon, **213.**

Anopheles vagus.

ASSAM.

Goalpara Dist., Haltugaon, **213**; **Manipur State**, Manipur, **209**; **Lakhimpur Dist.**, Limbuguri, **230**; **Sibsagar Dist.**, Tocklai, **228.**

BIHAR.

Bhagalpur Dist., *Bhaptiahi, **MB. 155-40**, Saharsa, **MB. 39-41**; **Darbhanga State**, *Benipatti, **MB. 13-45**, *Gangapur, **MB. 146-40**, *Madhepur, **MB. 23-41**;

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India Delhi.

Manbhum Dist., Chandil, **MB. 56-41,** *Dhanbad, **MB. 165-38,** Jharia, **214** ; **Muzaffarpur Dist.,** *Jaintpur, **MB. 41-41,** Muzaffarpur, **MB. 170-36,** *Patepore, **MB. 153-40** ; **Patna Dist.,** *Nekra, **MB. 48-37** ; **Purnea Dist.,** Barhara Kothi, Bhatotar Chakla, **MB. 40-41,** *Ishanpur, **MB. 150-40,** *Islampur, **MB. 7-41** ; **Ranchi Dist.,** *Bundagaon, **MB. 124-41,** Bundu, **MB. 127-41,** Palkot, **MB. 83-41,** *Silli, **MB. 99-41** ; **Santal Parganas,** Pakaur, **MB. 65-41** ; **Singhbhum Dist.,** *Chaibasa, **MB. 90-41.**

BOMBAY DECCAN.

Dharwar Dist., Dharwar, **MB. 13-42.**

BURMA LOWER.

North Arakan Coast, **203.**

CENTRAL PROVINCES EAST.

Udaipur State, Dharamjaygarh, **217.**

CEYLON.

Katugastota, **201,** Mahara (S.W.), **196a,** Rambukkana, Welimade, **201.**

EAST BENGAL (PAKISTAN).

Backergunge Dist., Lalmohan, **204a** ; **Nadia Dist.,** Haringhata, **204a** ; **Rangpur Dist.,** Palashbari, **204a.**

GUJARAT.

Surat Dist., *Surat, **MB. 13-46,** *Kerdi Road, Kola Amba, Vaghai (Dang State), **MB. 135-36,** Ahwa, **MB. 13-46.**

HYDERABAD NORTH.

Nizamabad Dist., Nizamsagar, **194.**

MADRAS COAST NORTH.

East Godavari Dist., *Cocanada, **MB. 12-37** ; **Vizagapatam Dist.,** Waltair, **225.**

MADRAS DECCAN.

Bellary Dist., Hospet, Sirigeri, Siruguppa, **215** ; **Kurnool Dist.,** Kurnool, **215.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Coonoor, Gudalur, Kallar, **218b** ; **Tanjore Dist.,** Pattukkottai, **219.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

MALABAR.

Malabar Dist., Chedleth, Kalpatta, Sultan's Battery, **199 ; Travancore State,** Kalthuritty, **MB. 38-38.**

ORISSA.

Balasore Dist., *Balaramgari, Santal Basti, **MB. 94-37,** Lakshmannath, **MB. 126-39 ; Ganjam Dist.,** Chatrapur, Dubrakudi, Kallikota, Konoka, Sabilia, Tolo Humma, **200,** Rambha, **222a ; Kalahandi State,** Lanjigarh Road, **208 ; Koraput Dist.,** Ambodala, Chitikona, Dondaparti, **221e,** Monikol, **221c,** Theruvali, **221a ; Puri Dist.,** Balugaon, **200,** Bharasapur (Pipli P. O.), **MB. 87-36,** *Darutheng-Chandka, **MB. 59-37,** *Dhanapur, **MB. 145-36,** Kesopur, **200,** Pratiasapur (Pipli P. O.), **MB. 130-36.**

UNITED PROVINCES EAST.

Faizabad Dist., *Faizabad, **MB. 46-43 ; Gorakhpur Dist.,** Gorakhpur, **MB. 160-36,** *Kunraghat, **MB. 114-38.**

UNITED PROVINCES WEST.

Nainital Dist., *Bazpur, **MB. 19-39.**

WEST BENGAL.

Birbhum Dist., Illambazar, **204a ; Calcutta Dist.,** Bally, **216 ; Darjeeling Dist.,** Kalimpong, **206,** Naksalbari, **204a ; Hoogly Dist.,** Arambagh, **204a ; Midnapur Dist.,** Egra, **204a,** Midnapur, **MB. 123-38 ; 24-Parganas Dist.,** Basirhat, **204a,** Dapa, **220b,** Falta, **220a,** *Ichapur-Nawabgunj, **MB. 120-36.**

Anopheles varuna.

BIHAR.

Bhagalpur Dist., *Bhaptiahi, **MB. 163-40,** Saharsa, **MB. 39-41 ; Darbhanga Dist.,** Gangapur, **MB. 159-40,** *Madhepur, **MB. 23-41 ; Hazaribagh Dist.,** Nayaserai, Sondimra, **221f ; Muzaffarpur Dist.,** *Muzaffarpur, **MB. 5-37 ; Ranchi Dist.,** Ranchi, **MB. 19-42,** Bundu, **MB. 132-41,** Jonha, **221f ; Singhbhum Dist.,** Gua, Kolhadi, Lolda, Posoita, Sarandha, Tangresai, **223.**

CENTRAL PROVINCES EAST.

Bilaspur Dist., Belghana, Bhanwar Tonk, Khodri, Khongsara, **222b ; Khairgarh State,** Acholi, Baidyatola, Bortalao, Chandsurat, Dongargarh, Panyajobi, **222b ; Korea State,** Chirmiri, Jhagrakhand, **221f ; Raigarh State,** Daghora, Himgir, Jamga, **221f.**

*** Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.**

CENTRAL PROVINCES WEST.

Balaghat Dist., Arnameta, Charegaon, Lamta, Padreganj, Sonkhar, **222b**; **Bhandara Dist.,** Darekasa, Goberwahi, **222b.**

CEYLON.

Chilaw, Giriulla, Mirigama, Puttalam, Trincomalee, **201.**

EAST BENGAL (PAKISTAN).

Chittagong Dist., Sitakund, **204b**; **Dacca Dist.,** Dhamrai, **204a**; **Faridpur Dist.,** Pangsa, **204b**; **Jessore Dist.,** Kotchandpur, **204b**; **Khulna Dist.,** Satkira, **204b**; **Mymensingh Dist.,** Iswarganj, **204a**; **Nadia Dist.,** Haringhata, **204a,** Tangail, **204b**; **Rajshahi Dist.,** Natore, **204b**; **Rangpur Dist.,** Palashbari, **204a.**

MADRAS COAST NORTH.

Vizagapatam Dist., Waltair, **225.**

MADRAS DECCAN.

Bellary Dist., Hospet, Sirigeri, Siruguppa, **215**; **Kurnool Dist.,** Kurnool, **215.**

MADRAS SOUTH-EAST.

Nilgiris Dist., Gudalur, **218b**; **Tanjore Dist.,** Pattukkottai, **219.**

MALABAR.

Malabar Dist., Kalpatta, **199**; **Travancore State,** Kalthuritty, **MB. 38-38,** Perumpazhuthoor, **207.**

MYSORE STATE.

Byrapura, Gargeshwari, Yedadore, **227.**

ORISSA.

Ganjam Dist., *Chatrapur, **MB. 161-39,** Dubrakudi, Konoka, Sabilia, Tolo Humma, **200**; **Kalahandi State,** Kakbhata, Lanjigarh Road, **221b**; **Koraput Dist.,** Ambodala, Bariguda, Chitikona Summit, **221b,** Dondaparti, **221e,** Jharsuguda, **221f,** Jimidiguda, Matkabadi, Muniguda (Monikol and Tikarapara), **221b,** Polypinda, **221c,** Porlupalam, **221e,** Rambha, **222a,** Theruvali, **221a**; **Puri Dist.,** Balugaon, Kesopur, Sana Nairi, **200.**

WEST BENGAL.

Birbhum Dist., Illambazar, **204a**; **Calcutta Dist.,** Bally, **216**; **West Dinajpur Dist.,** Phulbari, **204b**; **Hoogly Dist.,** Arambagh, **204a**; **Midnapur Dist.,** Chandrakona, **204b,** Egra, **204a**; **24-Parganas,** Adigunga, **204b,** Basirhat, Falta, **220a,** Gaurkhara, Malkapur, Paikpara, Sonarpur, Srikanda, Ukhila, **204c.**

---

* Denotes that a specimen from the locality in question is in the collection at the Malaria Institute of India, Delhi.

REFERENCES.

The numbers given are in continuation of the references in Puri's paper on distribution of anopheline mosquitoes in India, *Records of the Malaria Survey of India*, **6**, 2, 1936, pp. 177–211.

194. ABRAHAM, A. C., and SAMUELS, R. D. (1944). Epidemiology of Malaria in the Nizamsagar Ayacut Area, Nizamabad Dist., Hyderabad State. *J. Mal. Inst. Ind.*, **5**, 3, pp. 305–318.

195. AFRIDI, M. K., MAJID, S. A., and JASWANT SINGH (1938). Malaria in Kutch. *Ibid.*, **1**, 2, pp. 187–213.

196a. CARTER, H. F. (1930) ... Further Observation on the Transmission of Malaria by Anopheles Mosquitoes in Ceylon. *Ceylon J. Sc.*, **2**, pp. 159–176.

196b. *Idem* (1930) ... Observations on Epidemic Malaria in the South-Western Lowlands of Ceylon. *Ibid.*, **2**, pp. 177–189.

197. CARTER, H. F., and JACOCKS, W. P. (1929). Observations on the Transmission of Malaria by Anopheline Mosquitoes in Ceylon. *Ibid.*, **2**, pp. 67–86.

198. CLARK, R. H. P., and CHOUDHURY, M. A. (1941). Observations on *Anopheles leucosphyrus* in the Digboi Area, Upper Assam. *J. Mal. Inst. Ind.*, **4**, 1, pp. 103–112.

199. COVELL, G., and HARBHAGWAN (1939). Malaria in the Wynaad, South India. *Ibid.*, **2**, 4, pp. 341–376.

200. COVELL, G., and PRITAM SINGH (1942). Malaria in the Coastal Belt of Orissa. *Ibid.*, **4**, 4, pp. 457–593.

201. D'ABRERA, V. ST. E. (1944) ... The Eggs of the Ceylon Anopheline Mosquito. *Ibid.*, **5**, 3, pp. 337–359.

202. DE BURCA, B. (1946) ... Malaria in Fort Sandeman. *Ibid.*, **6**, 4, pp. 359–365.

203. GREWAL, R. S. (1937) ... Notes on the Anopheline Mosquito of Villages on the Arakan Coast of Burma. *Rec. Mal. Surv. Ind.*, **7**, 4, pp. 267-268.

204a. IYENGAR, M. O. T. (1939) ... A Year's Work of Dissection of Anopheles for Natural Malaria Infection. *J. Mal. Inst. Ind.*, **2**, 1, pp. 105–109.

204b. *Idem* (1940) ... Further Observations on Vectors of Malaria in Bengal and Notes on the Seasonal Infectivity of Anopheles. *Ibid.*, **3**, 1, pp. 115–123.

204c. *Idem* (1942) ... Studies on Malaria in the Deltaic Region of Bengal. *Ibid.*, **4**, 4, pp. 435–446.

205. JASWANT SINGH, and JACOB, V. P. (1943). Malaria in Ahmedabad. *Ibid.*, **5**, 1, p. 127.

206. KHAN, B. M. (1942) ... Malaria in the Tista Valley, Darjeeling Dist. *Ibid.*, **4**, 3, p. 421.

207. MATHEW, M. I. (1939) ... Anopheline Transmitters of Malaria in South Travancore. *Ibid.*, **2**, 1, pp. 101–104.

208. MONDAL, R. S. (1940) ... The Species Control of a Hill Stream by Training. *Ibid.*, **3**, 4, pp. 465–474.

209. MORTIMER, D. A. (1946) ... Notes on the Anopheline Fauna of Manipur Area, Eastern Assam. *Ibid.*, **6**, 3, pp. 269–271.

210. NICHOLLS, L. (1927) ... The Organization of Minor Anti-anopheline Field Work. *Ceylon J. Sc.*, **2**, pp. 31–36.

211. NEOGI, S. K., and KHAN, B. M. (1937). Winter Malaria Infection in the Bengal Dooars. *Rec. Mal. Surv. Ind.*, **7**, 3, pp. 213–219.

212. PANIGRAHI, R. G. (1942) ... Malaria in Puri. *J. Mal. Inst. Ind.*, **4**, 3, pp. 423–428.

213. PAUL, S. H., DAS, G. S., and ROY, S. C. (1936). A Brief Preliminary Report of the Malaria Survey of Haltugaon in the District of Goalpara, Assam. *Rec. Mal. Surv. Ind.*, **6**, 3, pp. 483–485.

214. RAO, G. R. (1941) ... Malaria in the Jharia Mining Settlement, Bihar. *J. Mal. Inst. Ind.*, **4**, 2, pp. 307–309.

215. RAO, R. B., RAO, H. R., and SUNDARESAN, B. (1946). Epidemiology of Malaria in the Tungabhadra Project Area of the Ceded Districts of Madras. *Ibid.*, **6**, 4, pp. 323–357.

216. ROY, D. N. (1939) ... The Importance of *A. varuna* Iyengar as a Carrier of Malaria in Bally (Calcutta). *Rec. Mal. Inst. Ind.*, **2**, 3, pp. 239–242.

217. ROY, D. N., and BISWAS, T. C. (1942). On the Importance of *Anopheles pallidus* as a Carrier of Malaria in Udaipur State, Central Provinces. *J. Mal. Inst. Ind.*, **4**, 3, pp. 417–420.

218a. RUSSELL, P. F., and JACOB, V. P. (1939). Epidemiology of Malaria in the Ennore-Nellore Coastal Area, Madras Presidency. *J. Mal. Inst. Ind.*, **2**, 2, pp. 131–152.

218b. *Idem* (1941) ... On the Epidemiology of Malaria in the Nilgiris District, Madras Presidency. *Ibid.*, **4**, 3, pp. 349–392.

219. RUSSELL, P. F., and RAO, T. R. (1940). On Habitat and Association of Species of Anopheline Larvæ in South-Eastern Madras. *Ibid.*, **3**, 1, pp. 153–178.

220a. SEN, P. (1937) ... ... The Relative Prevalence of Anophelines in Houses and Cattle-sheds in Deltaic Bengal. *Rec. Mal. Surv. Ind.*, **7**, 2 and 3, pp. 147–153.

220b. *Idem* (1938) ... ... *Anopheles sundaicus* (*ludlowi*) and Malaria in Calcutta. *J. Mal. Inst. Ind.*, **1**, 1, pp. 83–98.

221a. SENIOR WHITE, R. (1936) ... Williamson's 'Herbage Cover' Method of Larval Control. *Rec. Mal. Surv. Ind.*, **6**, 3, pp. 439–445.

221b. *Idem* (1937) ... Malaria Transmission in the Jeypore Hill Tracts—Part I. *Ibid.*, **7**, 1, pp. 47–75.

221c. *Idem* (1938) ... Malaria Transmission in the Jeypore Hills—Part II. *J. Mal. Inst. Ind.*, **1**, 1, pp. 129–145.

221d. *Idem* (1940) ... Studies on the Behaviour of Adult *A. culicifacies*—Part III. *Ibid.*, **3**, pp. 363–382.

221e. *Idem* (1941) ... Observations on the Adult Habits of *Anopheles fluviatilis* and *Anopheles varuna*. *Ibid.*, **4**, 1, pp. 57–62.

221f. *Idem* (1943) ... On Malaria Transmission in the Hazaribagh Ranges, Including Ranchi Plateau. *Ibid.*, **5**, 2, pp. 207–231.

222a. SENIOR WHITE, R., and ADHIKARI, A. K. (1939). On Malaria Transmission around the Chilka Lake. *Ibid.*, **2**, 4, pp. 395–423.

222b. *Idem* (1940) ... Malaria Transmission in the Eastern Satpura Ranges. *Ibid.*, **3**, 4, pp. 383–411.

223. SENIOR WHITE, R., and DAS, B. K. (1938). Malaria Transmission in the Singhbhum Hills. *Ibid.*, **1**, 2, pp. 169–184.

224. SENIOR WHITE, R., and NARAYANA, P. A. (1940). Malaria Transmission in the Singhbhum Hills—Part II. *Ibid.*, **3**, 4, pp. 413–425.

225. SENIOR WHITE, R., and RAO, V. V. (1943). Malaria Transmission around Vizagapatam. *Ibid.*, **5**, 2, pp. 187–205.

226. SUNDARESAN, B., and RAO, M. A. (1943). The Distribution of *Anopheles sundaicus* in Vizagapatam District. *Ibid.*, **5**, 1, pp. 107–112.

227. SWEET, W. C. (1937) ... A Study of Village Malaria in Mysore State. *Rec. Mal. Surv. Ind.*, **7**, 3, pp. 191–207.

228. THOMSON, R. C. M. (1940) ... Studies on the Behaviour of *Anopheles minimus*—Part I. *J. Mal. Inst. Ind.*, **3**, 2 and 3, pp. 265–294.

229. *Idem* (1940) ... Studies on the Behaviour of *Anopheles minimus*—Part III. *Ibid.*, **3**, 2 and 3, pp. 323–348.

230. VISWANATHAN, D. K. (1941) ... Experimental Malaria Control in a Hyperendemic Tea Garden in Upper Assam by the Use of Pyrocide 20 as an Insecticidal Spray. *Ibid.*, **4**, 1, pp. 35–55.

Indian Journal of Malariology, **2**, *3, September 1948.*

CONTENTS.

(All rights reserved.)

THE AMERICAN JOURNAL OF TROPICAL MEDICINE

Official organ of the American Society of Tropical Medicine.

Published bi-monthly, one volume each year. Established 1921.

Subscription price $5.50 per volume including postage, or Rs. 19-8.

The journal is read in the Union and in nearly 50 countries all over the world as a current record of the advances in tropical medicine. In addition to clinical, practical, and public health studies, material is included on chemistry, pathology, bacteriology, protozoology, helminthology, entomology, etc.

This policy of inclusiveness is restricted by the fact that the treatment of all subjects is strictly from the view-point of tropical medicine.

Orders can be placed directly with :

THE WILLIAMS & WILKINS CO.

Mt. Royal and Guilford Avenues, Baltimore, Md., U.S.A.

LINGNAN SCIENCE JOURNAL

This quarterly journal, published by the Lingnan University, offers original articles on biology, physical sciences, agriculture, public health, and related fields, in China. It is printed in English and other languages and each article has a Chinese abstract. The journal also includes a Book Review section and an extensive Abstracts section, in which an attempt is made to review the current periodical literature dealing with science in China. News is given of new publications, scientific expeditions and conferences under the heading of General Notes.

The Lingnan Science Journal prints over 700 pages a year and 16 annual volumes have been published. It may be secured through exchange or by subscription of $5.00 Chinese national currency, foreign U. S. $3.00. A sample copy will be sent on request. Manuscripts, subscriptions and inquiries should be addressed :

LINGNAN SCIENCE JOURNAL

Room 302, Science Hall

Lingnan University

Canton, China

ERRATA.

Indian Journal of Malariology, Vol. II, Nos. 1 and 2, March/June 1948.

Ray, A. P. ... PROPHYLACTIC USE OF PALUDRINE IN A TEA ESTATE.

Page 64, line 14, read *Trans. Roy. Soc. Trop. Med. Hyg.*, for *Trans. Trop. Med. Parasit.*,

---

Senior White, R. ... MALARIA TRANSMISSION IN THE LIGHT OF MODERN EVOLUTIONARY THEORY APPLIED TO MALARIA-CARRYING MOSQUITOES.

Page 14, line 23, *read* cathemerium *for* cathenerium.
Page 14, footnote, *read* Ungureanu *for* Ungureann.
Page 14, footnote, *read* albitarsis *for* albitaris.
Page 15, line 4, *insert* there *between* even *and* there.
Page 16, line 26, *read* speciation *for* specification.
Page 16, line 34, *read* Of birds *within* brackets.
Page 17, line 10, *delete* asterisk. *Read* Drosophila *for* Drosophilia.
Page 17, line 15, *read* Himalaya *for* Himalayan.
Page 17, line 19, *put* full stop *after* animal. *Read* For example *for* for example.
Page 17, line 21, *read* Limnaea *for* limnaea.
Page 17, footnote, read *autogenicus* for *anteganicus*. *Read* this footnote under page 18.
Page 18, line 35, *put* asterisk *after* mosquitoes. *Read* footnote of page 17.
Page 19, last line, *read* 1×10^6 *for* IXIo^5.
Page 20, line 39, *read* discontinuous *for* is continuous.
Page 21, footnote 3, read *elutus* for *elutus*.
Page 22, line 36, *put* full stop *after* species. *Read* Abundant *for* abundant.
Page 22, line 43, *read* members *for* member.
Page 23, line 15, *read* relicts *for* relics
Page 23, line 17, *put* full stop *after* sub-species. *Read* The *for* the.
Page 23, line 46, *insert* a *before* New Zealand.
Page 24, line 3, *begin* new paragraph *after* however.
Page 24, line 4, *read* Drosophila *for* drosophilia.
Page 25, line 33, *read* proof *for* period.
Page 25, lines 35, 42, 44, *read* speciation *for* specification.
Page 26, line 5, *read* is *for* was.
Page 26, line 40, *read* speciation *for* specification.
Page 26, footnote, read *maculatus* for *Maculatus*.
Page 27, line 1, *insert* we *after* but.
Page 27, line 27, *read* leading *for* lending.
Page 27, line 29, *read* Drosophila *for* drosophilia.
Page 29, line 42, *read* 21 *for* 11.
Page 32, line 14, *delete* been.
Page 32, line 12, under REFERENCES, *read* Antilles *for* antilles
Page 32, line 15, under REFERENCES, *read* F.M.S. *for* F.N.S.
Page 32, line 21, under REFERENCES, read *cathemerium* for *cathemarium*.
Page 32, line 23, under REFERENCES, *read* King, W. V. *for* King, L. V.
Page 33, line 19, bottom, *read* Ungureanu *for* Ungureann.

Indian Journal of Malariology, **2**, 3, September 1948.

A NOTE ON THE CHOICE OF SPRAYING EQUIPMENT IN MALARIA CONTROL WITH D.D.T. RESIDUAL SPRAYING.

BY

S. P. RAMAKRISHNAN, M.B.B.S., D.P.H.,

AND

V. RAMAKRISHNA, M.A.
(*Malaria Institute of India.*)

[April 16, 1948.]

INTRODUCTION.

VARIOUS workers in India and in other countries have recommended different types of sprayer for the application of D.D.T. residual spray. In India, Viswanathan and Parikh (1946) working in North Kanara (Bombay Province), although they used Ross pattern Four Oaks sprayers, were of the opinion that with this type of sprayer the application of D.D.T. is not uniform and that wastage of material is inevitable in the absence of highly skilled supervision. Puri (1947) recommended the use of stirrup pumps fitted with special nozzles for applying residual D.D.T. in rural malaria control, and Afridi and Bhatia (1947) carried out the experimental control of a number of villages in Baluchistan with the same type of equipment. The Ceylon Malaria Control Organization uses only knapsack sprayers for spraying residual D.D.T. in the entire island.

The equipment used for spraying surfaces with D.D.T. solutions, emulsions or suspensions has an important place in the economy of the control of malaria, and its choice to suit local conditions is as important as the modification of the universally applicable methods of malaria control. In order to determine the most economical method of malaria control suitable to the betelnut growing areas in the foothills of the Western Ghats, South India, it was considered necessary to compare the relative merits of different types of spraying equipment in common use.

A comparative study of the two types of spraying equipment—stirrup pumps and knapsack sprayers—was carried out and the result of this short study has

shown conclusively the need for intensive work on the choice of equipment to suit local conditions.

The area under investigation has many special features. The landlords live in large houses around each of which a number of huts for the tenants and labourers are built up. These houses are usually constructed apart from each other and the distance between any two is often half a mile or more. In the absence of any regular planning in the construction of houses or huts, the spraying teams cannot proceed in any definite direction when moving from one place to another as is usually possible in rural or urban areas in the plains. In the absence of well defined lanes or footpaths, the workers have to follow a zigzag course.

DATA.

Two types of sprayer in common use for residual D.D.T. spraying were employed in these trials. The knapsack sprayers used were of the Ross pattern Four Oaks type fitted with Woodford nozzles while the stirrup pumps were of indigenous manufacture of the type suggested by Puri (1947).

As a preliminary experiment, two houses were selected of which one was sprayed with a knapsack sprayer while the other with a stirrup pump. In both cases a 2·5 per cent D.D.T. water suspension (with gum and gelatine) prepared according to the Malaria Institute of India formula was used. The surface sprayed and the actual time of spraying were carefully recorded and the results are shown in Table I.

TABLE I.

Type of pump.	Number of men per pump.	Spraying time in minutes.	Area sprayed in sq. ft.	Dosage in c.c. per sq. ft.	Time taken to spray 1,000 sq. ft. with 2·5 c.c./sq. ft. in minutes.
Stirrup pump ...	3	35	2,881	3·3	9·2
Knapsack sprayer ...	1	40	5,949	2·3	7·3

Standardizing the data to two factors, namely a constant surface of 1,000 sq. ft. and a constant dosage of 62·5 mg. of D.D.T. or 2·5 c.c. of suspension per sq. ft., it was found that one man with a knapsack sprayer could spray this area in less time (7·3 minutes) than that taken by three men to spray a similar area with a stirrup pump (9·2 minutes).

To confirm the above results, trials on a large scale were undertaken in two selected villages. In one, knapsack sprayers applying 2·5 per cent D.D.T.-MKE water emulsion were used, while in the other 2·5 per cent D.D.T. water suspension was applied with stirrup pumps. Accurate record of spraying time and surfaces sprayed was maintained and the results are shown in Table II.

TABLE II.

Village.	Number and type of sprayer.	Number of men per pump.	Spraying* time in hours.	Number of dwellings sprayed, human/cattle.		Quantity of spray used in gallons.	Area sprayed in sq. ft.	Dosage of spray per sq. ft. in c.c.
Nidgal ...	3 stirrup pumps.	3	4·00	24	9	30 water suspension.	58,697	2·5
Mittabagulu	4 knapsack sprayers.	1	3·75	30	35	30 MKE emulsion.	61,133	2·4

* Spraying periods include the time taken for covering the distances from house to house in the area under study.

Standardizing the above figures as shown in Table III to 20,000 sq. ft. with a constant dosage of 2·5 c.c. per sq. ft. and to one sprayer, it was found that while 3 men with a stirrup pump took 4 hours 5 minutes to spray this area, one man with a knapsack sprayer was able to spray an equivalent surface in 5 hours 6 minutes.

TABLE III.

Pump.	Area sprayed in sq. ft.	Dosage per sq. ft. in c.c.	Spraying time in minutes.*
1 stirrup pump with 3 men ...	20,000	2·5	245
1 knapsack sprayer with 1 man ...	20,000	2·5	306

* Spraying periods include the time taken for covering the distances from house to house in the area under study.

A second field trial was made in another village to determine differences if any in the time taken in applying 2·5 per cent D.D.T. water suspension and 2·5 per cent D.D.T.-MKE water emulsion by the use of knapsack sprayers only. The results are tabulated in Table IV.

TABLE IV.

Spray.	Number and type of pump.	Number of men per pump.	Number of gallons.	Number of dwellings, human/cattle.		Spraying time* in hours.	Area sprayed in sq. ft.
Emulsion ...	4 knapsack sprayers.	1	7·8	5	5	2	15,259
Suspension ...	5 knapsack sprayers.	1	9·9	8	4	2	18,294

* Spraying periods include the time taken for covering the distances from house to house in the area under study.

From these observations it was obvious that there is no appreciable difference in the performance of knapsack sprayers, whether emulsion or suspension is used.

DISCUSSION.

The cost of malaria control in any area depends not only on the type of equipment used but also on the labour employed, supervision, transport and lastly on the type of country involved. From this experience it is clear that in the area under investigation the knapsack sprayer proved more economical than a stirrup pump for applying D.D.T. residual spray. The former is a one man unit while for the latter a team of three men is required. For various reasons the degree of co-ordination which should exist between the men in a team working a stirrup pump is not readily achieved. Puri (*loc. cit.*) is of the opinion that there is a factor of fatigue involved in the use of knapsack sprayers as compared to stirrup pumps, but in our opinion if the straps of the knapsack sprayers are so adjusted for each individual that the weight is equally distributed between the shoulders, the knapsack sprayer should not be more fatiguing than any other type of normal outdoor work. In the case of labour not physically robust as was the general condition of those employed in this area, the knapsack sprayer was not filled to capacity (3·5 gallons) but each sprayer was partially filled with the spraying fluid (2 gallons).

Another important factor to be considered before deciding whether knapsack sprayers or stirrup pumps should be used, is the problem of transport of spraying teams from village to village. Where labour is to be transported in a motor vehicle as in South Kanara a larger number of spraying units can be carried when knapsack sprayers are used.

A possible criticism against the knapsack sprayer may be that it is not conveniently possible to spray walls or ceilings beyond a height of 8 feet or more while one can do so with a stirrup pump. It will, however, be observed that in this area walls of a height of over 8 feet are rare. Moreover in areas where *A. fluviatilis* is the main carrier, it is not necessary to spray heights beyond 8 feet as this mosquito as observed by various workers is found to rest on walls more often nearer the floor than the ceiling. In case surfaces over a height of 8 feet are required to be sprayed, one of the two simple modifications to the knapsack sprayer may be adopted. The lance may be increased in length by joining a second piece to the spraying lance, or by increasing the length of the hose and tying the lance to a long wooden stick thus making it possible to spray surfaces over 12 feet high.

In the trials described in this note, it was found that the wastage of spraying material when knapsack sprayers were used was insignificant as compared to the loss in the use of stirrup pumps. In spite of all the care, spilling of emulsion or suspension from the buckets moved from place to place was unavoidable and in the absence of close supervision this wastage can result in considerable loss. It was found possible to train labour to spray surfaces uniformly with a knapsack sprayer at an approximate dosage of 50 to 65 mg. of D.D.T. per sq. ft., using a 2·5 per cent D.D.T. suspension or emulsion in a short time. Ordinarily a labourer is trained to spray the liquid to just wet the surface, but in the absence of adequate supervision he is likely to use the material more liberally. In such cases overdosage is likely to be more excessive in the use of stirrup pumps than with knapsack sprayers.

CONCLUSIONS.

The knapsack sprayer requires one individual to operate it and is therefore more economical to use than the stirrup pump for which a three man team is necessary especially in areas where labour is short, habitations scattered and communications are scanty.

Whether D.D.T. suspension or emulsion is used the efficacy of the knapsack sprayer is not impaired in any way.

Wherever it may be necessary to spray heights exceeding 8 feet the knapsack sprayer can be fitted with a longer lance, or by increasing the length of the hose, and supporting the lance by means of a stick.

ACKNOWLEDGMENTS.

The study presented in this article was made at the time the pilot scheme for malaria control in arecanut growing areas in South Kanara, financed by the Indian Council of Agricultural Research, was in progress.

The authors wish to express their gratitude to Lieut.-Colonel Jaswant Singh, Director, Malaria Institute of India, at whose suggestion and advice this work was undertaken.

The authors also wish to thank Mr. A. V. Annajee Rao, Malaria Inspector, and superior Field Worker Y. Constantine for their assistance in carrying out accurate measurements of the various factors.

REFERENCES.

AFRIDI, M. K., and BHATIA, M. L. (1947).	Malaria control of villages around Quetta with D.D.T. *Ind. J. Mal.*, **1**, 2, pp. 279–288.
PURI, I. M. (1947)	The practical application of D.D.T. for malaria control in rural and urban areas in India. *Ind. J. Mal.*, **1**, 1, pp. 211–220.
VISWANATHAN, D. K., and PARIKH, R. O. (1946).	Experimental rural malaria control measures in North Kanara District, Bombay Presidency, Part II. *J. Mal. Inst. Ind.*, **6**, 4, pp. 383–391.

Indian Journal of Malariology, 2, 3, September 1948.

CLINICAL TRIALS OF CAM-AQI IN MALARIA.*

BY

R. N. CHAUDHURI, M.B., M.R.C.P., T.D.D.,

AND

N. K. CHAKRAVARTY, M.B.

(*School of Tropical Medicine, Calcutta.*)

[May 25, 1948.]

CAM-AQI or camaquin is a light yellow crystalline powder, soluble in water and chemically related to quinacrine. It is a quinoline derivative, the chemical formula being 4(3′-diethalminomethyl-4′-hydroxyanilino)-7-chloroquinoline dihydrochloride dihydrate. The absorption, distribution and excretion of the drug is similar to that of quinacrine but it causes little or no staining of the tissues. In avian malaria CAM-AQI proved to be several times more active than quinacrine and the toxicity in laboratory animals is only about ¼ to ½ as much as that of quinacrine. The preliminary report of trials in human malaria appears to justify the claims based on animal experiments that it is an antimalarial drug of high potency and low toxicity. In the benign tertian malaria acquired in the South Pacific, 1 gm. of CAM-AQI given in 24 hours interrupted an attack without producing any toxic symptoms. Halawani, Baz and Morkos (1947) treated 42 cases (39 *vivax* and 3 *falciparum*) with 0·4 gm. in the course of two days and Simeons and Chhatre (1947) treated 50 cases (39 *vivax* and 11 *falciparum*) with single doses of 10 mg. per kilo body weight. In both the series the clinical course was promptly checked and no relapse occurred in the course of 2 to 5 months. Simeons and Chhatre also report that a single dose of 5 to 10 mg. per kilo body weight given to the boys of a mission hostel in a malarious area suppressed further attacks for two months or more.

It appeared that a new synthetic antimalarial drug for which such favourable claims are made deserved further study and the present report is based on the preliminary observations on the effect of the drug in 55 cases of human malaria. The study was undertaken particularly with a view to finding out the time taken to control an acute attack, the effect on asexual and sexual forms of parasites in the peripheral blood and the incidence of relapses. All the patients except one were admitted to the Carmichael Hospital for Tropical Diseases. Only those patients whose blood showed malaria parasites in fair or large numbers and who had no antimalarial drug previously were selected. The temperature of the

* Inquiry financed by the Indian Research Fund Association.

in-patients was recorded every four hours and thick blood films stained by Field's or J. S. B.'s technique were examined twice daily until the asexual parasites disappeared and thereafter once daily throughout the period of observation in the hospital. The present series comprises 23 *P. falciparum*, 23 *P. vivax*, 6 mixed *P. falciparum* and *P. vivax* and 3 *P. malariæ* infections. The distribution of race, age and sex in these groups is given in Table I.

TABLE I.

Race, sex and age of patients.

Infection.	Number of patients in each series.	Race.		Sex.		Age in years.	
		Indians.	Non-Indians.	Males.	Females.	Up to 12.	Above 12.
Falciparum (F)	23	22	1	22	1	2	21
Vivax (V)	23	23	0	22	1	1	22
Mixed (F–V)	6	6	0	6	0	1	5
Malariæ (M)	3	3	0	2	1	0	3

DOSAGE.

The drug is supplied in the form of tablets containing 0·05 gm. of the base, the actual amount of salt being 0·065 gm. In this article the drug will be referred to in terms of base and not salt. Two schedules of treatment were tried, the first schedule being 0·1 gm. (2 tablets) twice daily for three days and the second schedule, a single dose of 0·5 gm. (10 tablets). The latter was adopted following Simeons and Chhatre's observation that a single dose of 10 mg. per kilo body weight was the optimum amount necessary to terminate an acute attack. Since most of our adult patients were of about 50 kg. body weight, it was surmised that a dose of 0·5 gm. might be suitable for most of the patients. All patients above the age of 12 were given the adult dose. The dosage for the different groups is given in Table II.

TABLE II.

Dosage for different age groups.

Regime.	Above 12 years.	8 to 12 years.	4 to 8 years.	Below 4 years.
A ...	2 tab. b.d. for 3 days.	1½ tab. b.d. or 1 tab. t.d.s. for 3 days.	1 tab. b.d. for 3 days.	½ tab. b.d. for 3 days.
Total ...	12 tab. (0·6 gm.)	9 tab. (0·45 gm.)	6 tab. (0·3 gm.)	3 tab. (0·15 gm.)
B Single dose of	10 tab. (0·5 gm.)	7½ tab. (0·375 gm.)	5 tab. (0·25 gm.)	2½ tab. (0·125 gm).

However, all the patients on regime B and all except 4 on regime A were above 12 years of age and so received the adult dose. The 4 patients between 8 and 12 years of age received appropriately lesser amounts of the drug as indicated in Table II. Of the 54 cases admitted to the hospital, equal numbers were treated with regimes A and B and the one treated outside had regime B.

RESULTS.

The therapeutic response was very quick. The temperature came down to normal by the second day of treatment in 85 per cent of the cases and by the third day in 98 per cent. The peripheral blood was also rapidly cleared of asexual parasites which could not be seen beyond the second day in 83 per cent of the cases and beyond the third day in 100 per cent. The response to treatment in the 54 patients admitted to the hospital in regard to the temperature and the effect on the asexual and sexual parasites is shown in Table III.

TABLE III.

Effect of CAM-AQI on temperature and parasites.

Serial number.	Infection.	Last day of fever.	Last day of asexual parasites in the blood.	Duration of stay in hospital after treatment (days).	GAMETOCYTES.*	
					First seen.	Duration.
			Regime A.			
1	F	2	2	45	O	O
2	V	2	1	6	B	1
3	F-V	2	F2, V1	17	F2, VB	F16, V3
4	F-V	2	F1, V2	23	FO, VB	FO, V2
5	F	1	2	11	B	11*
6	F	3	2	14	O	O
7	F	2	2	34	B	26
8	V	2	2	12	B	3
9	F-V	1	F1, V1	8	FO, VB	FO, V1
10	F	1	2	5	O	O
11	V	1	2	11	B	3
12	F	1	2	37	O	O
13	F	3	2	11	O	O
14	F	2	3	15	B	12
15	F	1	3	13	3	11*
16	F	2	1	9	B	1
17	V	1	2	16	B	2

F = falciparum. V = vivax.

O = Gametocytes did not appear at all.

B = Gametocytes were present before treatment.

* after a figure indicates that the patient was discharged with gametocytes still present in the blood. The days are counted from the first day of treatment (1st column) and from the day of appearance of gametocytes after treatment (2nd column).

TABLE III—*concld.*

Serial number.	Infection.	Last day of fever.	Last day of asexual parasites in the blood.	Duration of stay in hospital after treatment (days).	GAMETOCYTES.*	
					First seen.	Duration.
			Regime A—*concld.*			
18	F	2	1	23	B	11
19	V	1	1	7	B	1
20	V	3	1	4	B	1
21	V	3	2	5	B	2
22	V	4	3	12	B	5
23	V	2	2	13	B	3
24	V	2	3	8	B	3
25	V	3	3	10	B	2
26	F	1	2	11	4	2
27	F-V	3	F2, V2	25	FO, VB	FO, V2
			Regime B.			
28	V	2	2	7	O	O
29	F	2	2	7	2	6*
30	V	2	1	7	B	2
31	F	2	2	9	B	2
32	V	0	1	14	B	1
33	F	1	2	8	B	4
34	V	3	2	32	B	2
35	F	2	2	14	O	O
36	F	1	3	16	3	13*
37	V	2	3	4	B	4*
38	M	1	2	32	B	2
39	F+M	1	F2, V1	7	FO, VB	FO, V1
40	V	2	1	34	B	1
41	F	1	3	20	B	20*
42	V	1	1	15	B	2
43	F	2	3	37	2	6
44	F	2	1	28	B	11
45	M	2	2	33	B	2
46	F	1	1	6	O	0
47	F	0	2	22	B	8
48	V	2	2	14	B	3
49	V	1	2	23	B	2
50	M	1	2	16	B	4
51	F	0	2	34	B	3
52	V	1	2	11	B	2
53	V	1	1	24	B	2
54	F+V	2	F2, V2	31	FO, VB	FO, V2

F = falciparum. V = vivax. M = malariæ.

O = Gametocytes did not appear at all.

B = Gametocytes were present before treatment.

* after a figure indicates that the patient was discharged with gametocytes still present in the blood. The days are counted from the first day of treatment (1st column) and from the day of appearance of gametocytes after treatment (2nd column).

The average duration of fever was 30 hours with regime A and 22 with regime B (excluding the 3 cases which were afebrile during and after the treatment). The average duration when parasites were seen in the peripheral blood was about 24 hours in either series.

It is evident, therefore, that CAM-AQI has a powerful parasiticidal action in human malaria and terminates an acute attack in a shorter time than with other antimalarials. The results are comparable to those of the chloroquine series (Chaudhuri, Rai Chaudhuri and Chakravarty, 1948) where chloroquine was used in about double the amount (1·25 gm.) in case of divided doses and treble the amount (1·5 gm.) in case of a single dose, the corresponding doses of CAM-AQI being 0·6 gm. and 0·5 gm. respectively.

The day-to-day effect of the two regimes of treatment on the temperature and asexual parasites is shown in Table IV.

TABLE IV.

Effect of treatment on temperature and asexual parasites.

Regime.	Number of cases.	Last day of fever.						Last day of asexual parasites in blood.				
		0	1	2	3	4	5	1	2	3	4	5
A	27	0	9	11	6	1	0	6	16	5	0	0
B	27	3	11	12	1	0	0	7	16	4	0	0
A–B	54	3	20	23	7	1	0	13	32	9	0	0

Two *falciparum* and one *vivax* case treated with regime B had no fever when the drug was given and no paroxysm occurred. They are indicated in the column 'O' of Tables IV and V. It will be seen from the above table that fever subsided by the second day in 85 per cent cases and only 13 per cent had fever on the third day and 2 per cent on the fourth. The asexual parasites were not seen beyond the second day in 83 per cent cases and persisted till the third day in the remaining 17 per cent. When the two regimes of treatment are compared it will be seen that the single-dose treatment interrupts an acute attack more quickly. The temperature was normal by the second day in 20 cases (74 per cent) treated with regime A and in 26 cases (96 per cent) treated with regime B. Also the asexual parasites were not seen after the second day in 22 cases (81 per cent) of regime A and 23 (85 per cent) of regime B. The clinical response with the two regimes of treatment is illustrated in Charts 1 to 6.

CHART 1.

Falciparum *malaria—regime A.*

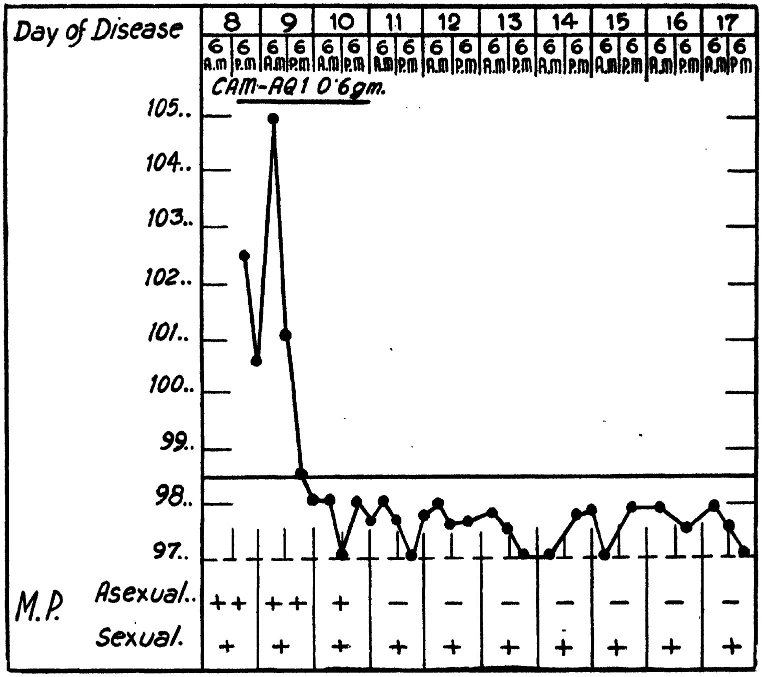


CHART 2.

Falciparum *malaria—regime B.*

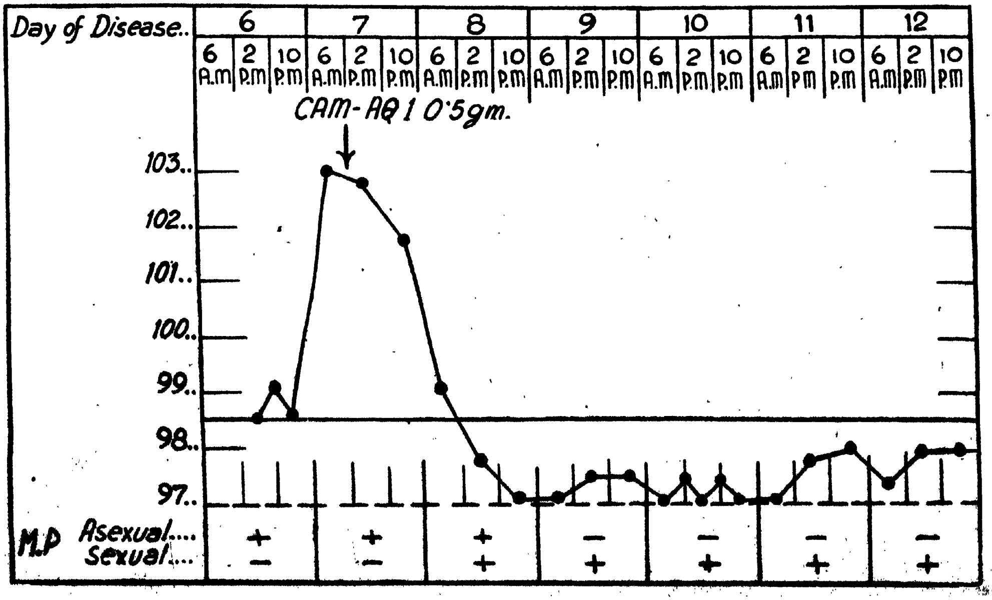


CHART 3.

Vivax *malaria—regime A.*

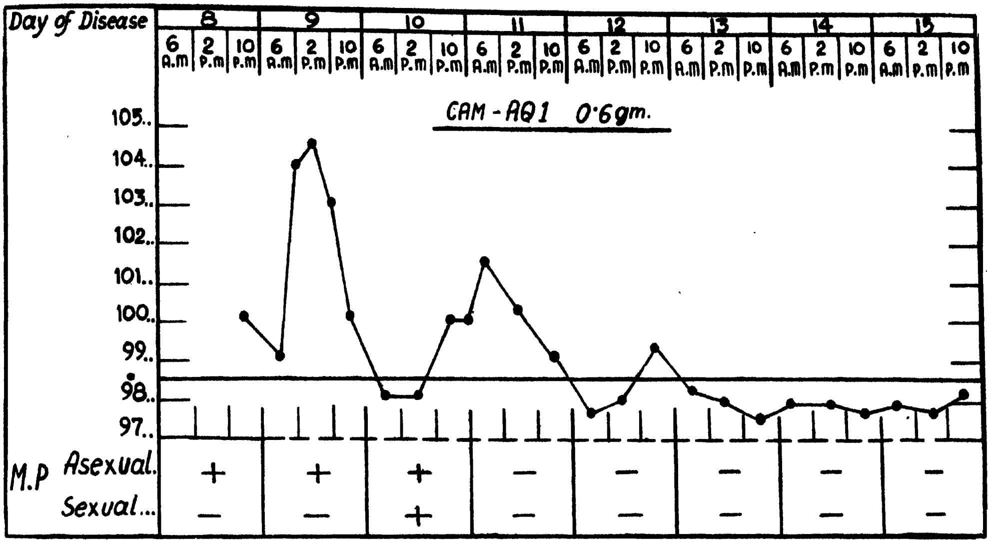


CHART 4.

Vivax *malaria—regime B.*

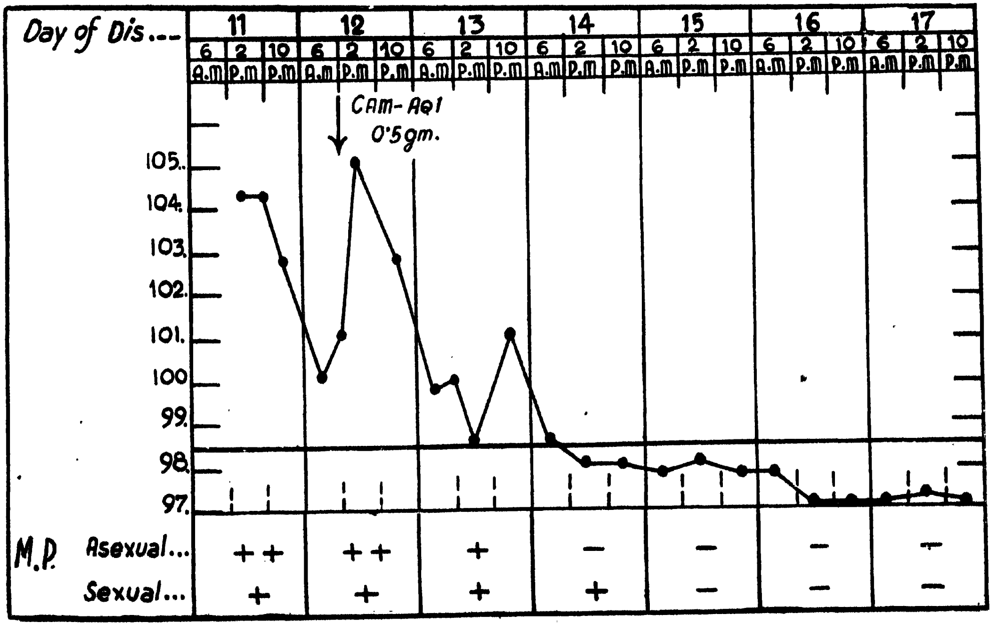


CHART 5.

Mixed falciparum *and* vivax *infection—regime B.*

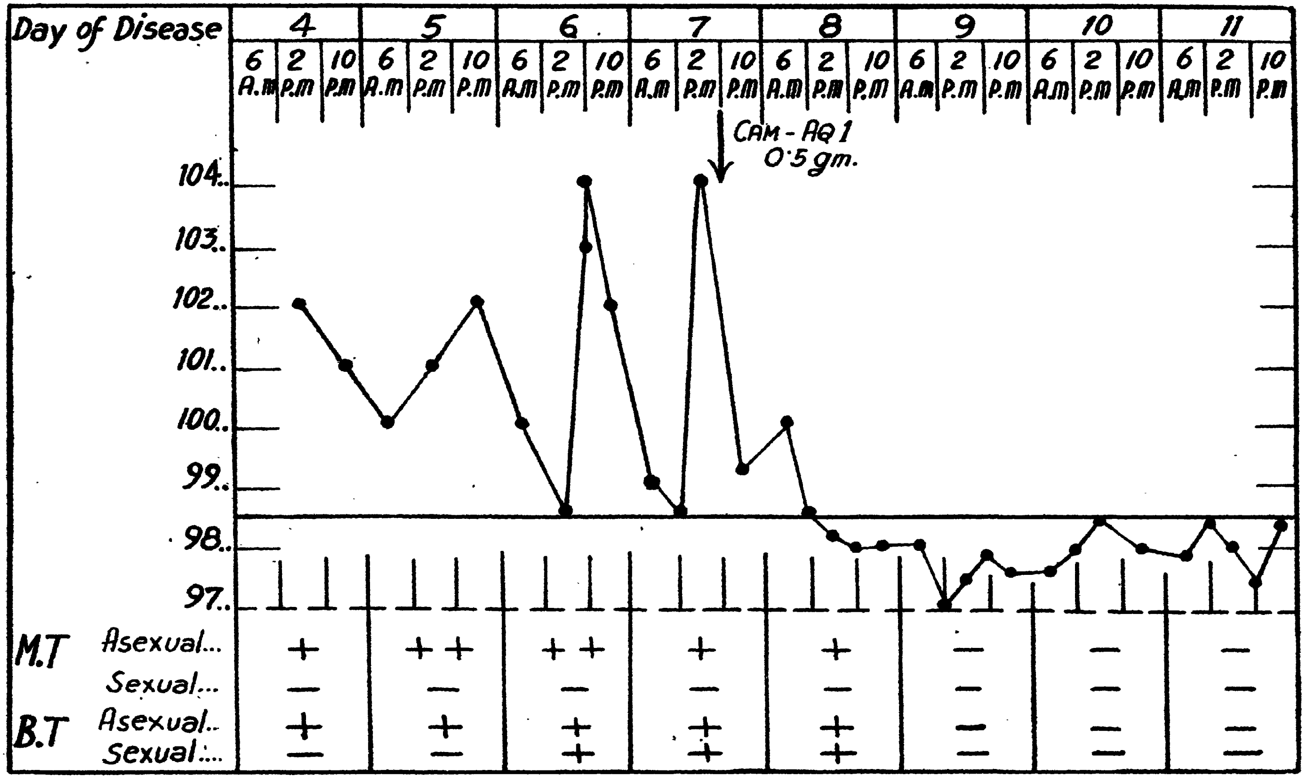
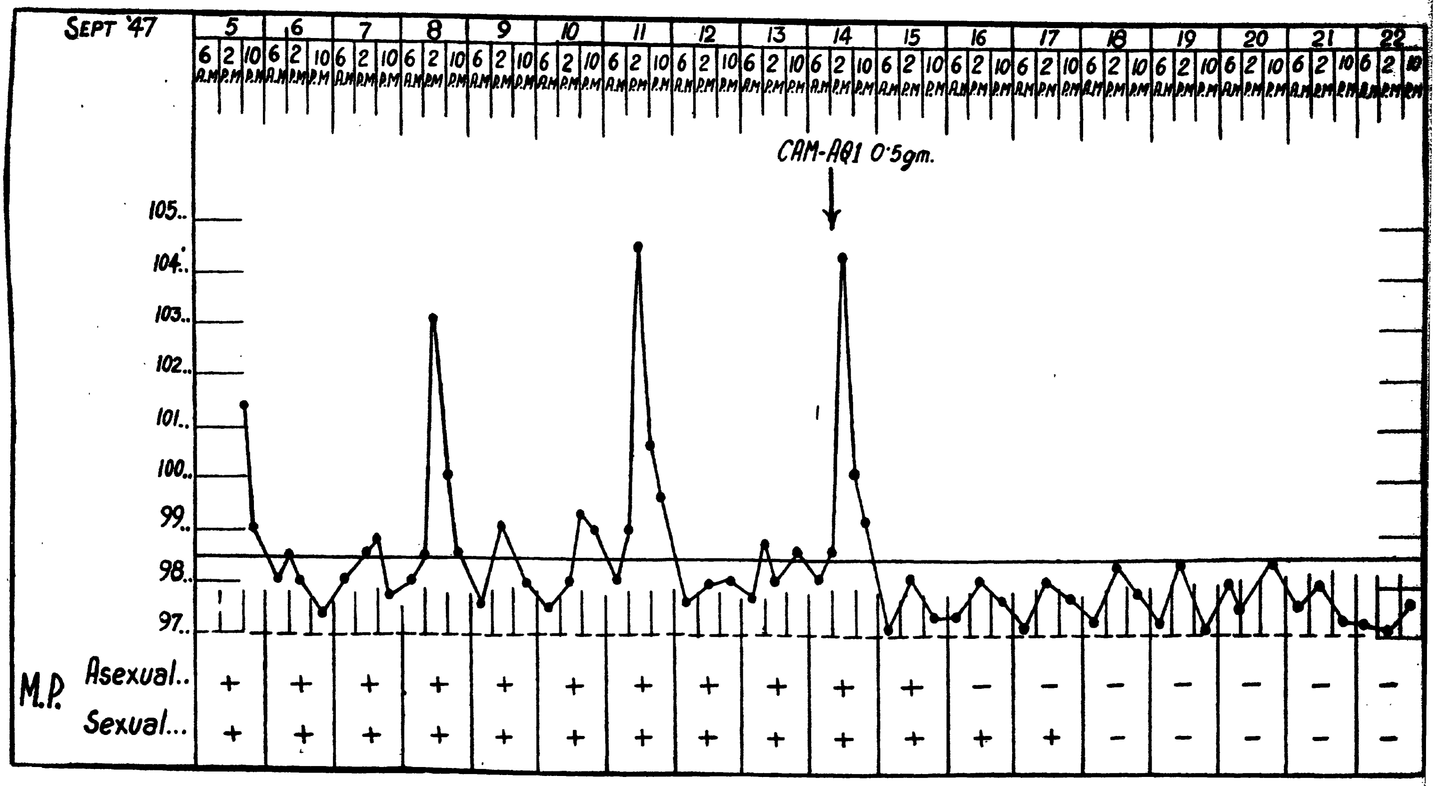


CHART 6.

Malariæ *infection—regime B.*



The efficacy of the drug separately in the three types of malaria commonly seen in India is shown in Table V.

TABLE V.

Type of parasite.	Number of cases.	Last day of fever.					Last day of asexual parasites in blood.			
		0	1	2	3	4	1	2	3	4
Vivax	22	1	7	9	4	1	8	10	4	0
Falciparum ...	23	2	9	10	2	0	4	14	5	0
Malariæ	3	0	2	1	0	0	0	3	0	0

Fever subsided in 2 days in 17 out of 22 *vivax* cases (77·3 per cent) and in 21 out of 23 *falciparum* cases (91·3 per cent), while asexual parasites disappeared in 2 days in 18 patients of either series (81·8 per cent in *vivax* and 78·3 per cent in *falciparum* infection). In all the 3 cases of *P. malariæ* infection, fever and parasites disappeared by the second day. Besides the 48 cases mentioned above, there were 6 cases with mixed *vivax* and *falciparum* infections. The order of disappearance of the asexual parasites in these cases is shown in Table VI.

TABLE VI.

Serial number.	Regime.	Parasites in blood.		
		First day.	Second day.	Third day.
1	A	F+V	F	O
2	A	F+V	V	O
3	A	F+V	O	O
4	A	F+V	F+V	O
5	B	F+V	F	O
6	B	F+V	F+V	O

F = falciparum. V = vivax.

It would appear therefore that there is not much difference in the action of the drug in *vivax* and *falciparum* infections and it is probably equally effective against all the three parasites.

RELAPSE.

The patients were in the hospital after treatment for periods varying from 4 to 45 days (up to 10 days in 17 cases, 11 to 20 days in 20 cases, 21 to 30 days in 7 cases and over 30 days in 10 cases) during which only one patient who had *falciparum* infection got a relapse on the 20th day after the original attack. After their discharge 19 patients could be followed up, including the patient who had been treated outside the hospital, and were under observation for 1 to 8 months (1 to 4 months in 8 cases and 4 to 8 months in 11 cases). Amongst them there were 8 relapses, 7 had parasites in the blood while one had febrile illness suggestive of malaria. Others remained free from attacks during these periods. Taking the 26 cases (8 treated with regime A and 18 with regime B) who were under observation for more than a month either in or outside the hospital, 8 had parasitic relapses and one a clinical relapse. As will be seen from Table VII they were more common with regime A than with B and incidentally all cases which relapsed had *P. vivax* infection either alone or with *P. falciparum* excepting in the case of recrudescences. It is however difficult to say whether all the cases were true relapses or some were reinfections.

TABLE VII.

Relapse cases.

Serial number.	Infection.	Regime.	Interval between 1st and 2nd attack.	Type of parasites in 2nd attack.	REMARKS.
1	F+V	A	5 months	M.P. +	Blood was examined elsewhere and type of parasite not mentioned.
2	V	A	30 days	V	... ...
3	F+V	B	40 ,,	V	... ...
4	V	B	50 ,,	V	The 2nd attack was also treated with regime B but she again had recurrence of *vivax* infection after an interval of 60 days.
5	V	A	5½ months	...	Blood not examined. He had low fever with chill for 3 days. Relieved by 2 doses of quinine mixture.
6	F+V	A	60 days	V	... ...
7	F	A	20 ,,	F	... ...
8	V	A	8 months	V	... ...
9	V	B	7 ,,	V	... ...

F = falciparum. V = vivax. M.P. = malaria parasites.

TOXICITY.

The drug was well tolerated by all patients and no untoward symptom was reported. It had no deleterious effect in cases with severe anæmia and in one case with red blood corpuscles white cells and plenty of albumin in the urine. Halawani and others treating their cases with 0·4 gm. refer to some toxic symptoms like gastro-intestinal irritation, palpitation, etc., which were 'trivial, rare, and of brief duration'. Simeons on the other hand did not notice any toxic symptoms. In this series also no toxic reaction was encountered in either of the two schedules employed. The single dose of 10 tablets was well tolerated and this amounted in some underweight subjects of the younger age group to as much as 20 mg. per kilo body weight. It should be the aim however not to give more than 10 mg. per kilo body weight and a single dose of this amount is quite safe and non-toxic.

GAMETOCYTES.

Of the 54 cases admitted to the hospitals, 6 had mixed *vivax* and *falciparum* infections. If the effect on the two types of parasite in these 6 cases is considered separately, the order of appearance and disappearance of gametocytes in the whole group is given in Table VIII.

TABLE VIII.

Type of parasite.	Number of infections.	Gametocytes did not appear in the blood.	Gametocytes were present before treatment.	Gametocytes disappeared during or after treatment.	Gametocytes disappeared in hospital.	Discharged with gametocytes.
F-V-M	60	13	41	6	40	7
F	29	12	11	6	11	6

F = falciparum. V = vivax. M = malariæ.

In *P. vivax* and *P. malariæ* infections the gametocytes disappeared in 1 to 5 days in all cases counting from the day the drug was administered. One *vivax* case however was discharged on the 4th day of treatment with gametocytes still present in the peripheral blood. Out of the 29 cases with *P. falciparum* infection either alone or with *P. vivax*, crescents had appeared in 17, in 11 before treatment and in 6 during or after treatment. Excluding the 6 cases who were discharged on the 6th to the 20th day after treatment with crescents still present and those where crescents never appeared in the blood, the average duration of the presence of the crescents in peripheral was 7·8 days, the range being 1 to 26 days.

Simeons and Chhatre report that there was no appearance of crescents in their crescent negative cases after treatment with CAM-AQI. In this series 6 cases with *falciparum* infection which showed only asexual forms of parasites before treatment developed crescents in 2 to 4 days after commencement of treatment and these parasites persisted from 2 to 16 days.

FIELD TREATMENT.

It would appear from what has been said above that regime B would be more suitable for mass treatment of malaria in rural areas. The single-dose treatment not only terminates an acute attack earlier than the other schedule but the relapse rate appears to be lower. As mentioned before, the tablets now supplied contain 0·05 gm. of the basic drug. But the patients may be reluctant to swallow 10 tablets at a time but this will be overcome if tablets containing a larger amount—(0·25 gm. or if this be too bulky 0·125 gm. with indentation in the middle)—can be marketed. This would enable the usage of the dosage schedule in regime B of Table II for different age groups using a maximum of 2 or 4 tablets and a minimum of half or 1 tablet.

SUMMARY.

1. The results of treatment of 55 cases of malaria with CAM-AQI have been presented.

2. Two regimes of treatment were tried: regime A, 0·1 gm. twice daily for 3 days and regime B, a single dose of 0·5 gm. These doses did not produce any untoward effect in any patient.

3. Fever subsided in an average period of 30 hours with regime A and 22 hours with regime B. Asexual parasites were not seen beyond an average period of about 24 hours with either regime. No other antimalarial drug interrupts an acute attack so quickly except chloroquine used in a much higher dose.

4. The drug had little or no action on the gametocytes. The *vivax* and *malariæ* gametocytes disappeared within 5 days after treatment while crescents were seen up to 26 days.

5. Out of the 26 cases kept under observation for 1 to 8 months, there were 8 parasitic relapses and 1 clinical relapse. Relapse was more frequent with regime A than with regime B. Reinfection however could not be definitely excluded in all cases.

6. The drug appears to be equally effective in *vivax*, *falciparum* and *malariæ* infections.

7. In view of the satisfactory response with a single dose CAM-AQI may prove a suitable remedy for mass treatment of malaria in rural areas.

ACKNOWLEDGMENT.

The authors wish to express their thanks to Messrs. Parke, Davis & Co. for the free supply of CAM-AQI.

REFERENCES.

CHAUDHURI, R. N., RAI CHAUDHURI, M. N., and CHAKRAVARTY, N. K. (1948).	*Ind. J. Mal.*, **2**, p. 1.
HALAWANI, A., BAZ, I., and MORKOS, F. (1947).	*J. Roy. Egypt. Med. Ass.*, **30**, p. 99.
SIMEONS, A. T. W., and CHHATRE, K. D. (1947).	*Ind. Med. Gaz.*, **82**, p. 255.

Indian Journal of Malariology, 2, 3, September 1948.

MEASUREMENTS OF MALARIA.

Part II.

SIMPLE STATISTICAL TECHNIQUE.

BY

SONTI DAKSHINAMURTY,

M.B., B.S., B.S.SC. (Madras), D.P.H., D.T.M. & H., Ph.D. (Lond.).

(Malaria Institute of India.)

[August 16, 1948.]

TABLE OF CONTENTS.

INTRODUCTION.

In a previous paper (Dakshinamurty, 1947) a plea was put forward that all observations made in the course of malaria surveys or during experiments on research problems in malariology be expressed as far as possible in numbers. In this paper simple statistical technique, essential for the treatment of figures which form the raw data, is described to enable one to draw relevant conclusions. Several methods of statistical technique have been developed during recent years, and it is proposed to outline only the simple and more important ones for students of malariology. This subject is considered under two main heads: (I) Arrangement and Presentation of Data, (II) Statistical Calculations.

SECTION I.—ARRANGEMENT AND PRESENTATION OF DATA.

1. *Tabulation of data.*—The results of the first stage of any inquiry are a few fairly simple figures which can be easily presented and understood without any special treatment. However, as the enquiry proceeds there is an overwhelming mass of data and detail. The first task of the statistician is to analyse these in the two senses of reducing the amount of detail, and bringing the data into a form whereby the salient and significant features stand out prominently and the unimportant details are suppressed. The process is essentially one of summarizing. The first and foremost step in the statistical reduction of data is therefore to group into a class items which need not be distinguished, and when many items are put into groups in this way they are said to be classified. Sometimes the subject falls easily and naturally into a few categories, but often the classes have to be created more or less arbitrarily. In making such classification, three points should be borne in mind:

(*i*) Any body of results can usually be classified in many ways, and the best will depend on the purpose of the enquiry which is only possible with a special knowledge of the subject under investigation.

(*ii*) The second point which follows the whole idea of classification is that each class should be fairly homogeneous.

(*iii*) With regard to the number of groups, it is not desirable to have too many fine classes or to have too few broad classes. A good practical rule is neither to exceed 20 nor keep to less than 10, and about 15 is a good number to remember. Too many classes defeat the very object of classification, while too few will not give homogeneous groups in each class. When data are collected they must be arranged in some kind of tabular form so that particular factors may be easily studied and compared. The individual observations are too numerous to allow their meaning to be grasped. The preparation of tables is of primary importance in statistical work. We may have to deal with qualitative or quantitative data and both can be tabulated, the former requiring more skill and care. In grouping, the main difficulty lies with 'border line' cases owing to personal factors introduced in the collection of the data of a qualitative character.

2. *Special tables: frequency distribution.*—When we deal with a large number of observations as explained above, we have to class them into groups perhaps 10–20 with some convenient group-interval in the first column, and the number of individuals in each group in the second column. Such a table is called a *frequency table* and such a tabulation reduces the jumble of figures to some order (Example 1). A frequency distribution is an economical summary of a mass of recorded figures, and it reduces chance to some order in which the mind can comprehend. The first desideratum of arrangement or presentation of statistics is a frequency distribution, that is, a table showing the frequency with which individuals with some defined characteristic or characteristics are present. The important step is to think in terms of the frequency distribution and abandon the habit of thinking in terms of averages. Unless and until the investigator does this his conclusions are likely to be faulty. The two essential elements underlying a frequency distribution are: (1) the things that are counted called the *individuals*, and (2) the quality or quantity that is measured and defines the classes, called the *character*. A frequency table may be better grasped by a *frequency curve* which is drawn from the frequency table in the form of a graph with the character on the abscissa, and the number of individuals on the ordinates (Diagram 4). The main thing to notice about the diagram or the curve of a frequency distribution is its general shape, given by the position of its peak and its width. With the help of a frequency distribution a statistician can sum up a 'statistical situation' even as a clever cartoonist with a few strokes of his pen can bring out the main features of a person caricatured. Indeed, the things we need to know about such a body of observations are not really many or complex, we need know only three things: (*i*) whether there is a well-defined typical value of the character, and if so what that value is, (*ii*) to what extent the individuals vary about that type, and (*iii*) whether the variation extends equally above and below that type. These facts are readily seen from and described by a frequency table and better from a frequency curve or diagram. We can compare two frequency distributions if we know the statistical averages and the standard deviation, or variability with which the observations are scattered around the mean, and lastly the symmetry or asymmetry of the distribution. Some typical types of frequency diagrams are given in Diagram 2 illustrating the points discussed above.

3. *Histograms.*—A frequency distribution is represented graphically by a column diagram known as a histogram. This consists in marking the group intervals or character on X-axis, and the number of individuals on the Y-axis. These are joined by short lines to form columns corresponding to different groups, and this is called a column diagram or histogram (Diagrams 1 and 3).

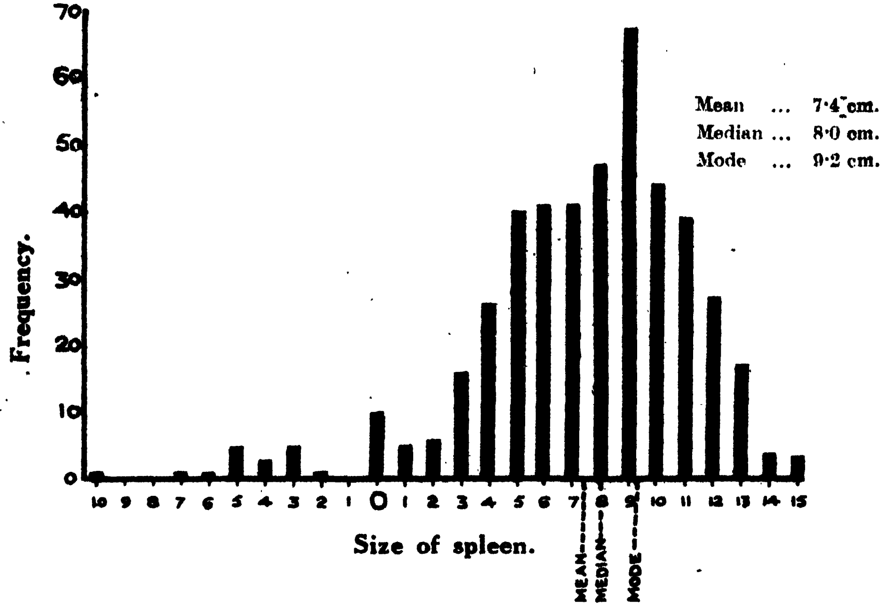
Instead of representing in columns, the tops of all these columns may be joined by a smooth curve imagining the group intervals to be small enough, and then we get the frequency curve already described. This is a very important curve in statistics as we have to deal later with the 'normal frequency curve' which is the sort of curve we get from all anthropometric data, say for example, heights or weights of school children (Example 3) or wing lengths of Anopheles (Diagram 4) or measurements of enlarged spleens (Example 2).

Diagram 1.

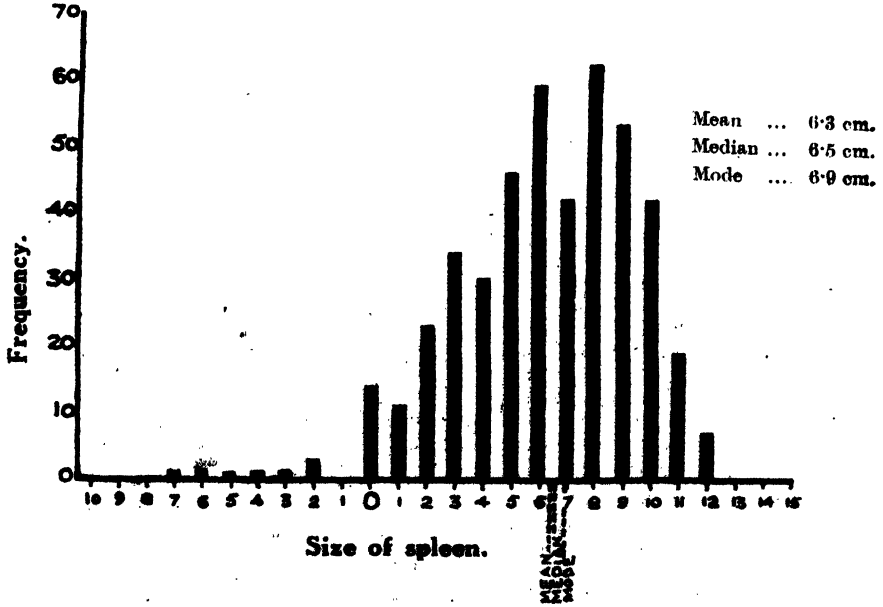
Average enlarged spleen.

A. Apex-umbilicus measurements.

Histograms showing mean-median-mode (calculated from frequency distributions in Example 1).



B. Apex-median line measurements.

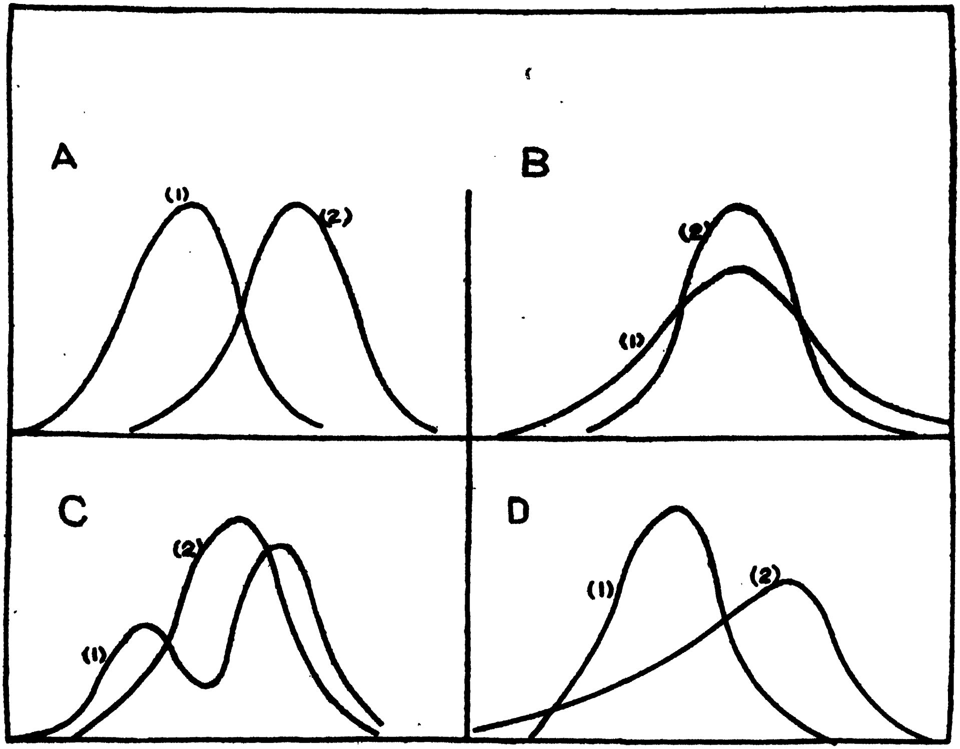


4. *Graphs, diagrams and charts.*—There is an art in arranging a table to present data economically and clearly, and in a way to facilitate any comparisons that the reader may be required to make, while graphs, diagrams and charts are

DIAGRAM 2.

Types of frequency distributions (after Tippett).

The character is represented in the direction → (Abscissa), and the frequency in the direction ↑ (Ordinates).



A. The typical value of (2) is higher than that of (1), but both distributions show the same degree of variation. The overlap of the curves shows that some individuals in (1) have higher values than some in (2).

B. The typical value is approximately the same for (1) as for (2), but (1) shows the greater degree of variation. There are more very high and very low values in (1) than in (2).

C. The distribution of (1) shows a mixture of two well-defined types, whereas (2) shows homogeneous variation.

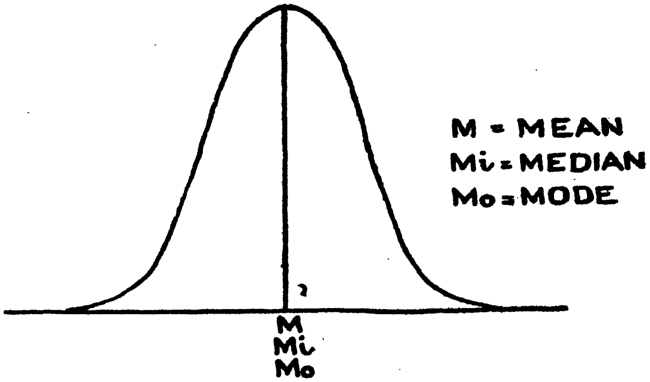
D. The typical value of (2) is higher than that of (1), but the variation in (2) is greater in degree and is asymmetrical in form, so that there are more very low values in (2) than in (1).

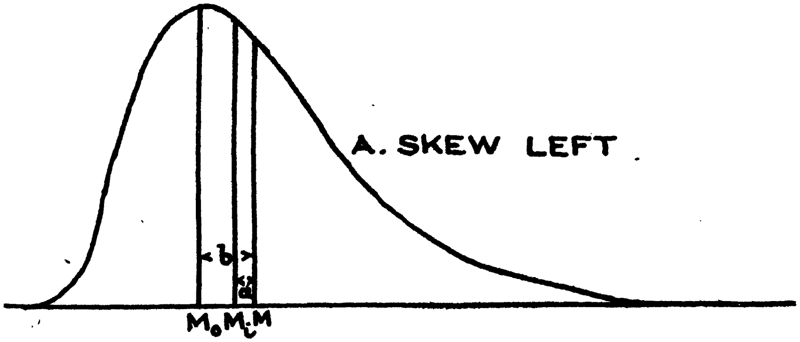
also much used in presenting statistics, and have a value because even statistical ones give some delight to the eye and a spark of interest to a paper. Their chief importance however is that they give a picture of the broad statistical facts that

Diagram 2a.

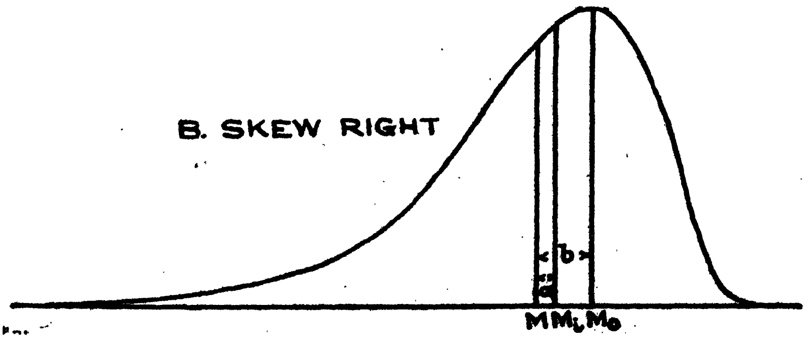
Position of mean, median and mode in symmetrical and asymmetrical distributions.

I. Symmetrical distribution.





II. Ideal moderately asymmetrical distributions.



Mode = Mean-3 (mean-median) or in other words, the median lies one-third of the distance mean to mode, from the mean towards the mode, i.e. $a = \frac{1}{3}b$ in the diagram.

The mean lies on the side of the greatest frequency towards the longer 'tail' of the distribution.

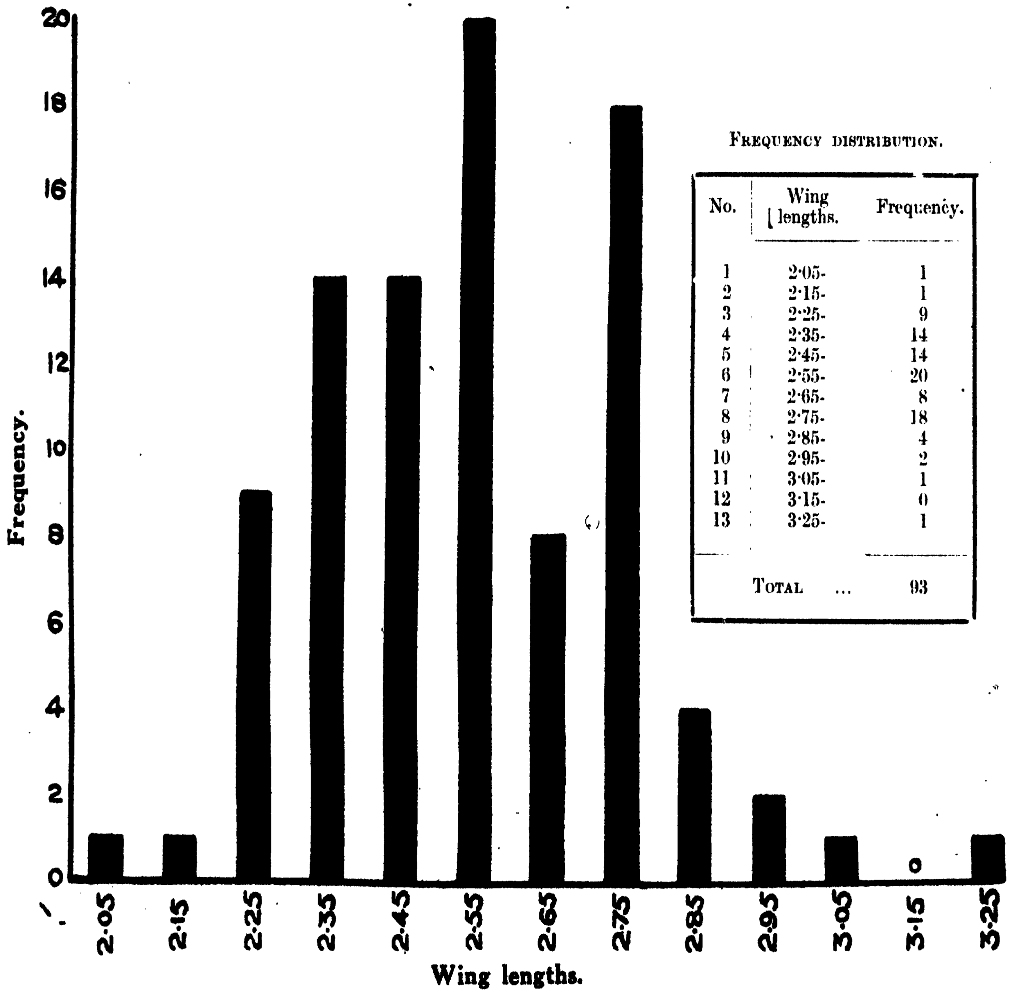
The mode is the maximum of the curve.

is more readily taken in than a table. Magnitudes are more easily appreciated and remembered when conveyed to the mind by pictures than by numerical figures. On the other hand, the broad picture given by a graph, diagram or chart

DIAGRAM 3.

Histogram of wing lengths of Anopheles.

(Rajindar Pal, 1945.)



FREQUENCY DISTRIBUTION.

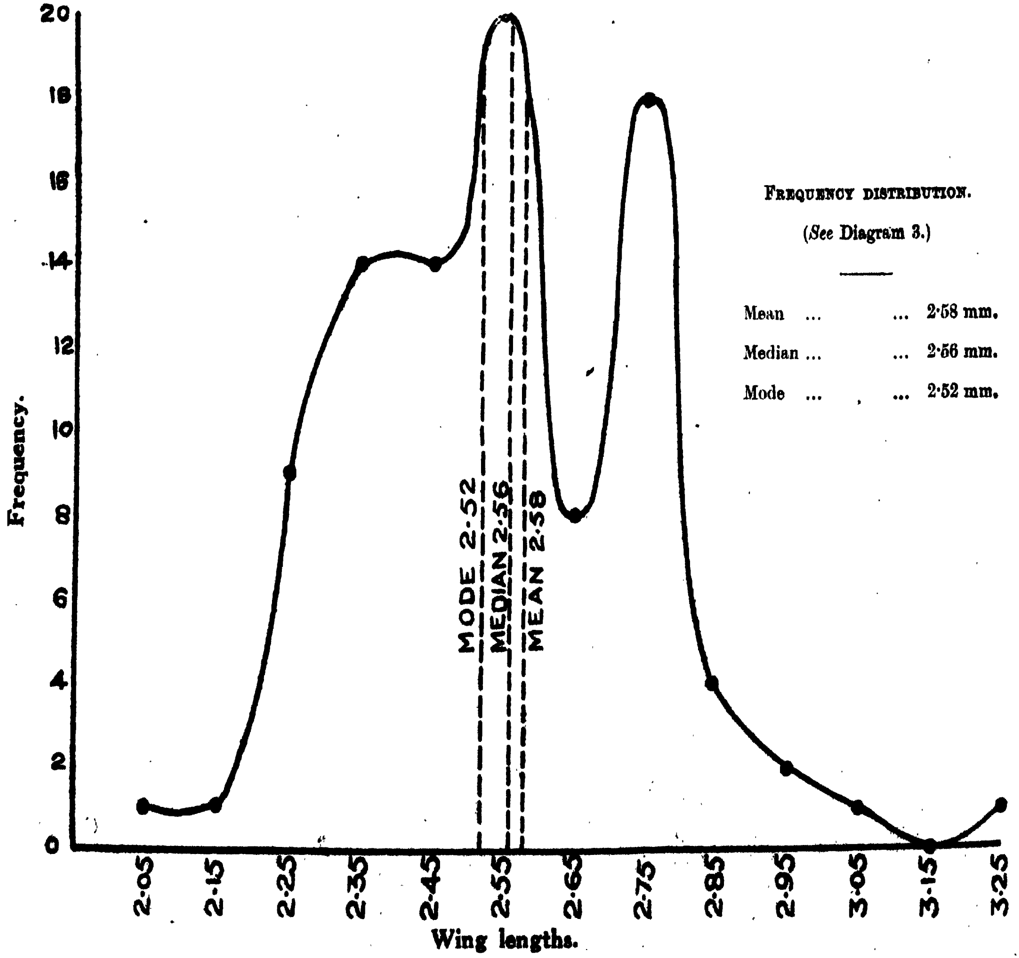
No.	Wing lengths.	Frequency.
1	2·05-	1
2	2·15-	1
3	2·25-	9
4	2·35-	14
5	2·45-	14
6	2·55-	20
7	2·65-	8
8	2·75-	18
9	2·85-	4
10	2·95-	2
11	3·05-	1
12	3·15-	0
13	3·25-	1
	TOTAL ...	93

is not as exact in detail as that given by a table of figures, and since it is somewhat affected by the way in which the diagram is made it may even give a misleading impression if wrong scales or too much information is put on it. As a

graph and a table have their own specific purposes, a table should never be omitted when a graph is given. There are many types of graphs and the choice of a particular type depends on the data to be charted. The simplest graph is that in which the observations are represented by points plotted on a chosen scale and

DIAGRAM 4.

Frequency curve of wing lengths of Anopheles showing the mean, median and mode.

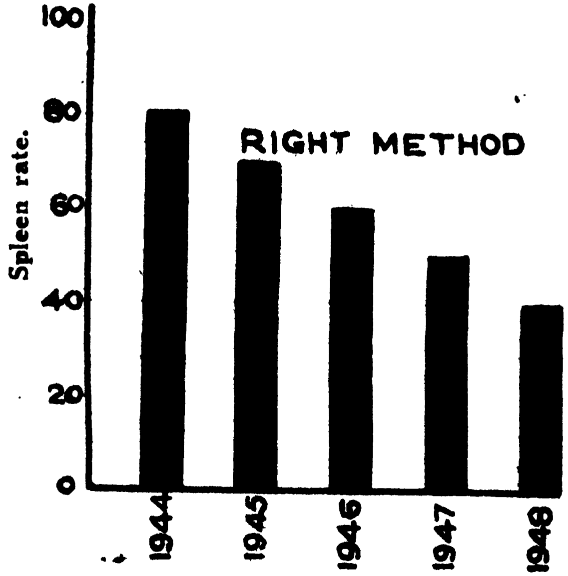


joined by a series of straight lines. In fixing the scales, we must remember that if we are comparing two curves, the difference will be exaggerated if we expand the vertical and contract the horizontal scales, and minimized if the process is reversed. We must select or choose a scale which does not have either effect.

The statistician chooses his scale according to the impression he thinks the figures should convey and that impression of course depends on the object for which the figures are being used. The person who receives the statistical information has also an active part to play, for he needs to know how to read tables and diagrams and to understand their meaning, and the more critically is he able to examine

DIAGRAM 5.

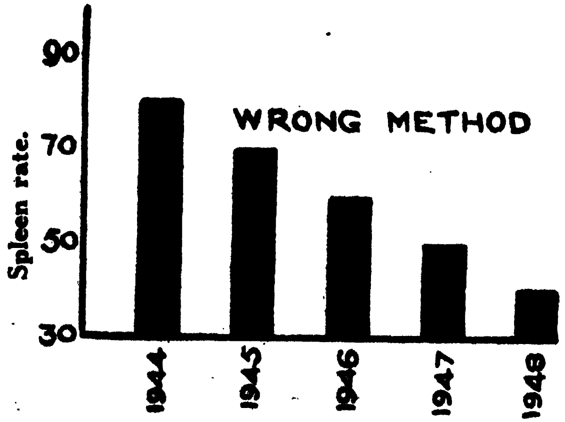
Graphs illustrating wrong impression given by starting with a scale other than zero on the ordinates.



YEARLY DECREASE IN SPLEEN RATES.

Year.	Spleen rates.
1944	80
1945	70
1946	60
1947	50
1948	40

The reduction is only from 80 to 40 (one-half) but in the wrong method it looks as if it is reduced to one-fifth.



them, the less likely is he to be led astray. Just as people have to learn making and reading a map, students must be taught to read graphs and charts correctly. For example, graphs should be drawn always with 0 on the ordinates, otherwise very misleading conclusions may be drawn. As an illustration may be given the decrease in spleen rates during five consecutive years from 80 per cent in 1944 to 40 per cent in 1948, which is actually halved, but may be given the impression that they are reduced to a fifth by starting the scale on the ordinates at 30 per cent instead of at 0 per cent (Diagram 5).

5. *Bar diagrams.*—The next type is called a bar diagram to indicate the relative importance of any two particular factors for a series of years. As an

DIAGRAM 6.

Deaths from fevers and malaria per 100,000 *of population in rural and urban areas of United Provinces,* 1936–1944.

Bar diagram.

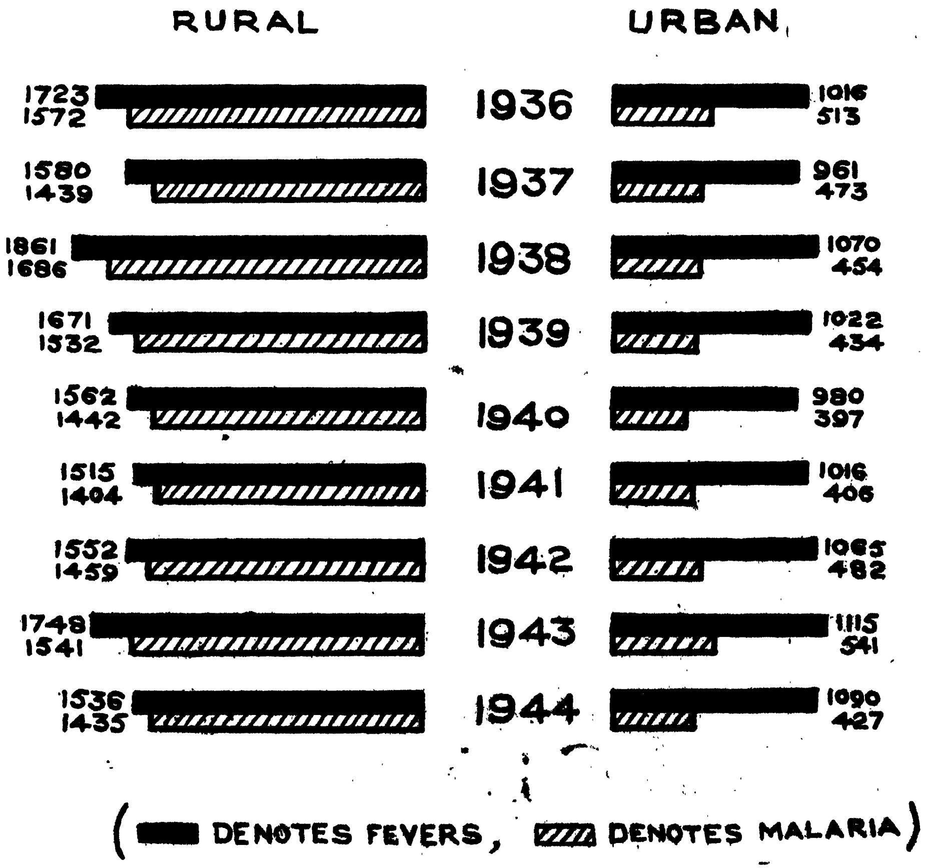


illustration may be taken deaths from rural and urban areas from malaria and as malaria is a rural disease, the former are likely to exceed the latter, and the contrast can be shown by two bars running parallel and close to each other (Diagram 6).

6. *Pictorial diagrams and spot maps.*—For depicting various problems, pictorial diagrams of different kinds are used which may appeal to school children, or say the lay public who wish to go round a public exhibition within a short time. Spot maps are sometimes useful as they depict facts in space, e.g. the daily occurrence of cases or deaths from a certain disease in a town indicating the course of an epidemic.

In all work relating to graphs, charts and diagrams these points should be remembered; select the best type of graph, chart or diagram, and try to depict the main issues clearly without putting too much on the graph or diagram, and do not consciously or unconsciously mislead the reader by manipulation of scales, or by other means to bring out any wrong impression which may be the most obvious, but not necessarily the relevant conclusion.

SECTION II.—STATISTICAL CALCULATIONS.

These may be broadly divided into (*a*) Measures of position, and (*b*) Measures of dispersion.

A. Measures of position.

(1) *Statistical averages: mean, median and mode.*

There are three forms of average commonly used in statistical work—the arithmetic mean, the median and the mode. The arithmetic *mean* is the simplest and the most commonly used average. It is the sum of a series of values divided by the number in the series. The *median* is the middle value of a series when arranged in order of magnitude, or it may be defined as the point above and below which exactly 50 per cent of the observations fall. If the number of terms is even, there is strictly speaking no median; in that case we average the two mid-most values. The *mode* is the most frequent or typical value of a series, in other words it is the 'fashion' of the series. The mean is affected by abnormal occurrences while the median and mode are not so affected, the median and mode are located in the series where the observations are most dense, and hence their value over the mean in certain conditions (Example 2 and Diagram 1).

(*a*) *Mean*—If the number of observations is large, say greater than 50 or 100, instead of adding up each value to find the mean, it is quicker to arrange them in a frequency distribution, and then calculate the mean. The choice of the interval depends upon the range of the observations, and it is advisable to choose an interval as already explained so that the total number of groups is not less than 10 or greater than 20. To find the mean of a grouped series of observations all the values in each class are treated as though they were identical with the mid-value of the class interval, and it is assumed that the mean lies in a group near the middle of the range. We calculate the deviations in units instead of the actual mid-values of the class intervals. The deviation of the

group in which the assumed mean is taken is represented by zero, that of the next group of less magnitude by — 1, etc., that of the group of greater magnitude by + 1, etc.. in other words, we scale the groups above and below the zero group in units. These deviations in working units are then multiplied or weighted by the corresponding frequencies, the number of observations in each class interval and the products summed with regard to sign. The result divided by the total number of the observations gives us the average deviation in working units from the arbitrary mean. Then we multiply the average deviation by the class interval to bring it to the proper dimensions. The mid-point of the group in which we placed our arbitrary mean is taken, and the correction made to get the true mean (Examples 3 and 4).

(*b*) *Median* is easily ascertained from a frequency distribution. If the data are sorted on cards, one can select the heap in which the median will fall, and count the cards in order up to the required number (Example 2).

(*c*) *Mode* cannot be calculated from a frequency distribution by any simple method. It can be gauged approximately from a frequency curve where the curve turns at its height. It can be got from the formula—

Mode = Mean-3 (mean-median).

It will be noticed that there is very little difference between these three statistical averages, mean, median and mode, in a symmetrical frequency distribution, that is one in which the class frequencies decrease fairly evenly on either side of a central maximum, while in an asymmetrical distribution they will differ—the difference being greater as asymmetry increases. In such a distribution it is obvious that the mode and the median are more important forms of average than the mean.

Example 2 and Diagram 1 give frequency distribution and histograms respectively of the apex-umbilicus and the apex-median line measurements of

FROM EXAMPLE 2.

Average.	Apex-umbilicus.	Apex-median.
Mean	7·4 cm.	6·3 cm.
Median	8·0 cm.	6·5 cm.
Mode	9·2 cm.	6·9 cm.

450 adult convicts in Andamans. It is usual to calculate only the mean to signify the 'average enlarged spleen', but here the 'average' is taken to signify the three statistical averages, mean, median and mode, and all the three averages were calculated thus.

From this it is clear that in case of the apex-umbilicus measurements, the median and the mode are quite different from the mean being an asymmetrical distribution. It is of some value in epidemiological studies to get an idea of the 'median' spleen and the 'mode' spleen in addition to 'mean' spleen. However, in the apex-median measurements given above, the mean, median and mode are not very different. It is suggested that wherever any asymmetry is observed in spleen measurements, all the three averages should be calculated. For example, it has been shown that the calculation of the value of a mode is as necessary as the mean value, and that bi-modal spleens are common under certain endemic malaria conditions (Macdonald, 1931).

(2) *Statistical indices : rates, ratios and percentages.*

Rates, ratios and percentages are the simplest statistical quantities, and express the value of one quantity *relative* to another. These are used when the actual values of the quantities themselves may be a mere detail, while the figures relating to a certain common base may be the point at issue, e.g., in comparing the health of two towns by means of deaths we do not want to compare the total deaths in the towns but the deaths per 1,000 (called deaths per mille) of the population of each town, as the populations may be different. Similarly, if we wish to compare the rate of the same town in several successive years when the population is changing, we use the death rate per mille of the population over several years. In general, these indices are used where the absolute figures are irrelevant, and they require to be superimposed over some base such as the population at risk. All rates are usually calculated per 1,000 of the population but they may be taken for convenience of expression in whole numbers for 10,000, 100,000 or even a million to obtain in convenient whole numbers where rates are taken for a big country. There is only one rate which is calculated as a percentage, and that is the case-mortality rate. It is important to remember that all these are rather tricky quantities as they may alter due to changes either in the value of the numerator or in the denominator, or a simultaneous change in both numerator and denominator with or without any change in the value of the fraction as a whole. One must be on guard in interpreting rates that suitable allowance is made for such changes.

B. Measures of dispersion.

(*i*) Of a single variable :

(1) ***Standard deviation :***

When the arithmetic mean of the observations has been calculated we next proceed to ascertain the degree or extent to which the observations are scattered around this value. Are they closely concentrated around the mean or do they tend to spread away from the mean ? It is very necessary to have some idea of this variation because the arithmetic means of two series of observations may be

the same or quite different. Take as a simple illustration the apex-umbilicus spleen measurements of two groups of ten children as follows :

Apex-umbilicus measurements of two groups of children.

Number of child.	Group A.	Group B.
	cm.	cm.
1	1·0	2·5
2	1·5	2·8
3	2·1	3·2
4	2·5	3·2
5	3·2	3·3
6	3·5	3·3
7	4·1	3·5
8	4·5	3·6
9	5·1	3·8
10	5·5	3·8
TOTAL ...	33·0	33·0
Average enlarged spleen.	3·3	3·3

The mean of both groups is 3·3 cm. but the range of splenic measurements in group A is from 1·0 to 5·5 cm. and in group B from 2·5 to 3·8 cm. There is obviously a much greater variation in the splenic measurements of group A than in group B, and this difference in range is valuable in epidemiological studies of the two groups. We wish to measure this variation or scatter of the measurements around their mean value. This measure of dispersion or scatter is known in statistics as the standard deviation.

The range.—The simplest way is to find the range between the highest and lowest values but this method alone is unsatisfactory as the extent of the range depends upon the size of two extreme cases only, and furthermore it gives us no idea of the *form* of the distribution.

The mean deviation.—We can obtain a measure of the variability by calculating the mean deviation, i.e., we calculate the deviation of each observation from the mean value, sum these deviations *irrespective of sign*, and take their

average. The result is called the mean deviation. Suppose 10 boys secured the following marks in an examination:

Number of student.	Number of marks.	Deviation from mean.	Square of deviation from mean.
1	10	−45	2,025
2	20	−35	1,225
3	30	−25	625
4	40	−15	225
5	50	− 5	25
6	60	+ 5	25
7	70	+15	225
8	80	+25	625
9	90	+35	1,225
10	100	+45	2,025
TOTAL ...	550	250 (disregarding signs).	8,250

Range = 10 to 100 marks.

Mean $= \dfrac{550}{10} = 55$

Mean deviation $= \dfrac{250}{10} = 25$

Standard deviation $= \dfrac{8,250}{10} = \sqrt{825} = 28{\cdot}7$

Although the mean deviation is simple to calculate and is at the same time a fairly accurate measurement of dispersion, nevertheless, the process of its calculation is algebraically unsound because the signs are disregarded. For this and for other reasons it is replaced by another measure of deviation known as the standard deviation. This is known as the yard-stick of the statistician, and is the most important single measure in statistics.

Standard deviation is the square root of the mean of the sum of squares of all deviations, the deviations of course being measured from the arithmetic mean or average of the observations. It is also termed the root-mean-square deviation. A large standard deviation signifies that the frequency distribution spreads out from the mean, while a small standard deviation shows that the observations are closely concentrated around the mean.

Calculation of standard deviation.

(*a*) *Standard deviation of an ungrouped series.*—This can be done by three methods as shown in Example 3.

Method I.—In the example, the mean is 40. To find the standard deviation we first find the deviations from the mean (and these should add up to 0), then square these deviations to get rid of the difference of sign, then sum up the last column and divide by 10. This gives the mean of the square of the deviation and then find the square root of this number, which gives the standard deviation.

Method II.—It sometimes happens that the figures are closely dispersed round one figure, say systolic blood pressure of persons scattered around 100 mm. In this case it is quicker to work out deviations around this figure than from the mean.

Method III.—Sometimes it is quicker to work directly with the variates and square the observations themselves using any mathematical table of squares, then subtract the square of the mean of the observations from the mean of the observations squared, and take the square root of this number.

(*b*) *Standard deviation of a grouped series.*—If we require the standard deviation of a grouped series or in other words of a frequency distribution, we proceed on lines similar to those adopted for the calculation of the arithmetic mean of a grouped series. We assume an arbitrary value for the mean and then calculate the deviations of the actual observations from the assumed value, but instead of expressing the deviations in their proper magnitude we measure them in a unit scale for simplicity. Each deviation in the unit scale is then squared and weighted or multiplied by the number of observations in the corresponding group. These values are then summed up, and the result is divided by the total number of observations. The square root of the quotient gives us the standard deviation in working units around our arbitrary origin. From this we can calculate the standard deviation around the true mean (Example 4).

(2) *Coefficient of variation :*

It is often necessary to compare the relative degrees of variation in two frequency distributions which are measured in different kinds of units, say the heights of children compared with their weights, or one has to compare frequencies measured in the same units but with different means, e.g., the relative variabilities of weights or heights at different ages. Suppose we wanted to know whether a group of children were more variable with respect to height than with respect to weight, we cannot directly compare inches and pounds. Similarly, we may like to ascertain for epidemiological studies whether a group of children are more variable to spleen measurements than parasite counts when both are expressed as frequency distributions, and we cannot compare directly spleen measurements with parasite counts. However a relative measure can be obtained by expressing the standard deviation as a percentage of the mean in each case, the result is the standard deviation of the distribution expressed as a percentage of the mean of the distribution, i.e., coefficient of variation which is $= \frac{\text{Standard deviation}}{\text{Mean}} \times 100$. If the standard deviation is 10 around a mean of 40, then the former value is 25 per cent of the latter, but if the standard deviation is 10 and the mean 400, the former value is 2·5 per cent of the latter. Similarly, the means may be the same but standard deviations different, which gives different coefficients of variation.

(*ii*) Of two variables :

(1) Coefficient of correlation.

(2) Coefficient of regression.

(1) *Coefficient of correlation :*

So far we have described a single variable. It is clear that in a frequency distribution of a single variable of heights or weights of children, or the wing lengths of Anopheles, or the splenic measurements of enlarged spleens, the mean and standard deviation adequately described the frequency distribution. The next problem is to measure the degree of correlation or association between *two* variables. We require to know if large values of one variable co-exist with large or small values of the other variable, or that no such relation exists.

When two sets of figures of two variables are arranged in a table, with one set of one variable in the vertical line of the table and another set of the other variable in the horizontal line of the table, certain features relating to the clumping of these figures in the body of the table may be noticed. The word correlation or association connotes both the tendency for a connection between two characters to show itself, as well as the deviation from that tendency. If there is a pronounced association in either way, it is shown by a tendency for all frequencies to occur in cells of the table about one diagonal, and this gives the whole table a characteristic appearance. If there is no association, or what is called dissociation, no such clustering of figures is noticeable, but a wide scatter all over the table. Such a clustering or scatter may be strong or weak and gives an idea of the correlation coefficient, maximum correlation is 1 and minimum 0, and intermediary stages are represented by figures ranging from 0·1 to 0·9. Association between two quantities is called correlation, and the figure which measures such correlation is called a correlation coefficient. When the two quantities tend to increase together, the correlation is said to be positive, if one tends to increase while the other decreases the correlation is negative. Whether positive or negative correlation the appearance of clustering of figures in a table about one diagonal is the same, when positive it is the one diagonal and when negative it is the other (Example 5).

It should be remembered that correlation like all statistical results merely describes the relation within a given set of data referring to a particular set of conditions taken at a particular time. It will be a mistake to generalize from such results. For example, there is a correlation between ages of husbands and wives but not between their heights, as couples consider ages at their marriage but do not generally mind their heights. Lastly, it is very important to remember that correlation does not establish causation. A historic example of this blunder in the science of malariology is that malaria and marshes were considered directly correlated, and for long ancients concluded that marshes caused malaria, and hence the origin of the name 'mal-air' to malaria.

The calculation of the correlation coefficient is given in Example 6 where the correlation between spleen rates and general death rates in 9 districts in Mauritius was shown by Sir Ronald Ross as long ago as 1911. The correlation coefficient was found to be +0·84 which is a high positive correlation. The correlation diagram (Diagram 7) illustrates the trend of these two rates, and it is obvious from this diagram that with the rise and fall of one there is a corresponding rise and fall in the other, although naturally the waves in spleen rates are more marked than those in the death rates.

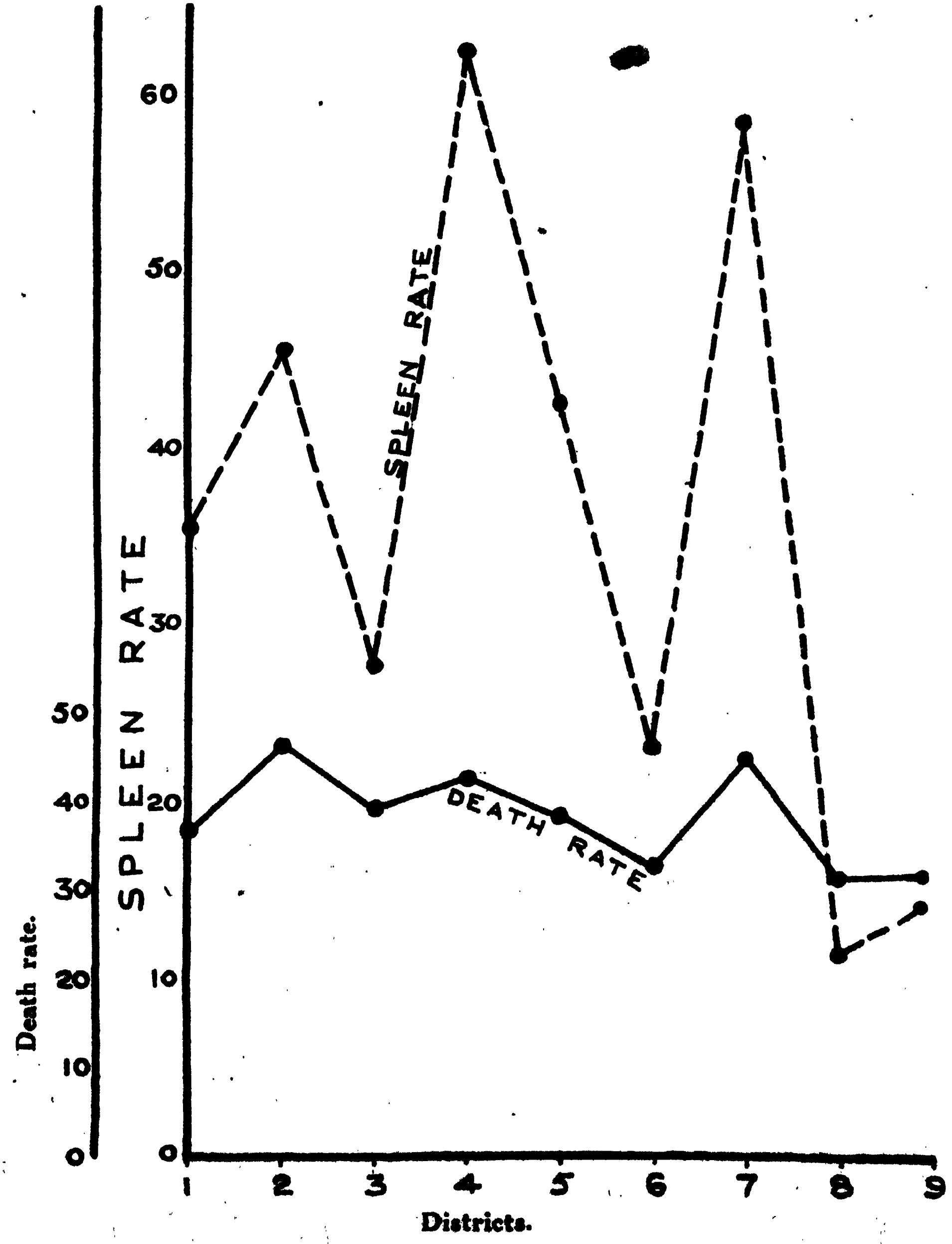
DIAGRAM 7.

Correlation between death rates and spleen rates.

(Sir Ronald Ross, 1911.)

Trend Diagrams.

(Data from Example 4.)



(2) *Coefficient of regression :*

The correlation coefficient measures the degree of association or dissociation between several pairs of observations: it is a measure of individual variability in terms of average variability. The regression coefficient, however, gives the average change in one variable corresponding to a unit change in the other variable, and is therefore a useful measure in certain problems.

The average dispersion of the different values of the spleen rates and death rates in the nine districts is measured by the standard deviation. To calculate the regression coefficient between these two rates, we need the actual standard deviations of these two variables and the correlation coefficient. Theoretically there are two regression coefficients, as indicated below :

(1) Regression coefficient of death rates in terms of spleen rates is given by :

$\frac{\text{Standard deviation of death rate}}{\text{Standard deviation of spleen rate}} \times$ correlation coefficient of spleen rate and death rate.

(2) Similarly, the regression coefficient of spleen rates in terms of death rates is given by :

$\frac{\text{Standard deviation of spleen rate}}{\text{Standard deviation of death rate}} \times$ correlation coefficient of spleen rate and death rate.

These regression coefficients are calculated in Example 7.

It is evident from the range of these rates that there is a much larger variation with spleen rates than with death rates. Thus the regression coefficient for spleen rate for unit variations in death rate is 2·77. while the regression coefficient for death rate for unit variations in spleen rate is only 0·25. However, in practice it is only necessary to calculate one regression coefficient. In this case, as it is easy to ascertain in a short time the spleen rate of a village in a malarious locality, one may wish to ascertain the death rate from this by means of a regression coefficient. This is obtained easily from the regression equation and regression line described below :

(*i*) *Scatter diagram.*—This is a graph upon which each individual set of readings is entered as a point or a dot, the position of each point being determined by the values observed in the individual for the two characteristics measured, e.g., death rates and spleen rates, each dot represents the associated death rate and spleen rate for each district, giving nine dots on the whole (compare Diagrams 8 and 9).

(*ii*) *Regression equation and regression line.*—The scatter diagram shows the general trend of the various points, and it is possible to draw an imaginary line which passes through as many points as possible and leaving other dots equally dispersed on either side of this line. It is easy to calculate the equation for this line, and draw one which gives the best fit to the scatter diagram. This is termed the regression equation, and the resulting line the regression line. In this case the equation is of the form $Y = ax + b$, and the regression line is therefore a straight line.

From the equation (death rate-mean death rate)

= regression coefficient (spleen rate-mean spleen rate)

Substituting D for death rate and S for spleen rate,

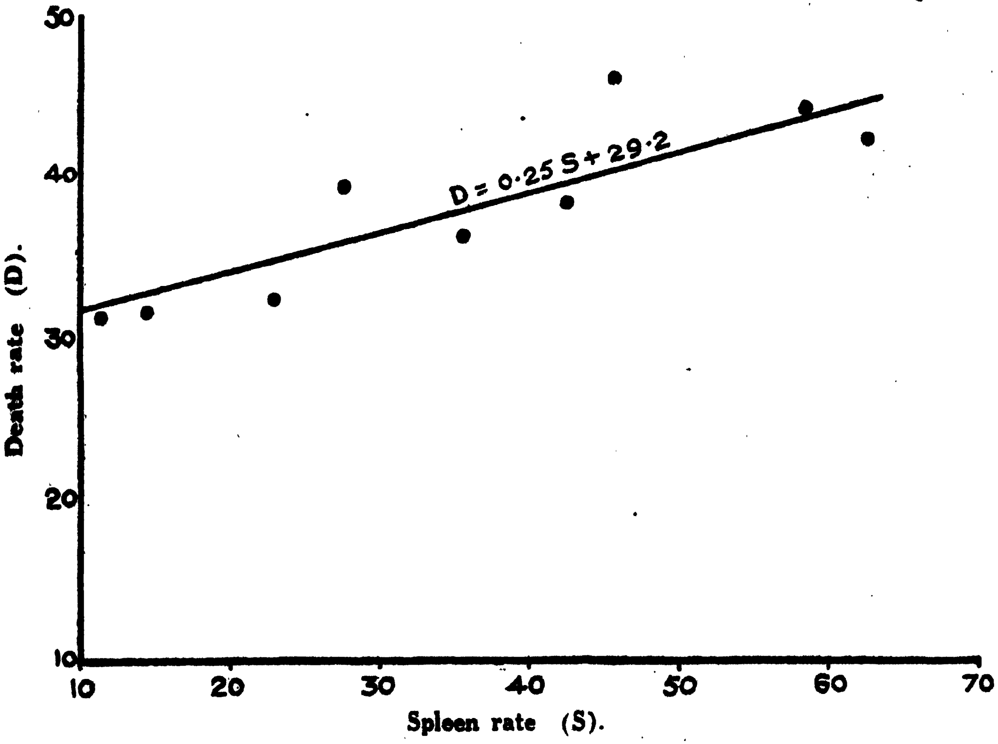
$$D - 38{\cdot}1 = 0{\cdot}25\ (S - 35{\cdot}6)$$

Simplifying, we obtain the regression equation,

$$D = 0{\cdot}25\ S + 29{\cdot}2$$

DIAGRAM 8.

Regression line and scatter diagram between death rate and spleen rate.
(Data from Example 4.)



Giving various values to S, we obtain corresponding values for D, as below :

Spleen rates.	*Death rates.*
S = 10	D = 31·7
S = 20	D = 34·2
S = 30	D = 36·7
S = 40	D = 39·2
S = 50	D = 41·7
S = 60	D = 44·2
S = 70	D = 46·7

Plotting these points we get the regression line as in Diagram 7. From this we can convert any values of spleen rates from death rates or *vice versa*.

ACKNOWLEDGMENTS.

Free use has been made of books referred in Part I of this paper.

REFERENCES.

COVELL, G., and BAILY, J. D. (1927). ... *Ind. J. Med. Res.*, **15**, 2, pp. 309-326.

DAKSHINAMURTY, S. (1947) ... *Ind. J. Mal.*, **1**, 2, pp. 301-305.

MACDONALD, G. (1931) ... *Ind. Jour. Med. Res.*, **18**, pp. 1347-1372.

RAJINDAR PAL (1945) ... *J. Mal. Inst. Ind.*, **6**, 2, pp. 239-241.

RONALD ROSS (1911) ... *The Prevention of Malaria.* John Murray, London.

WOOD, H. M., and RUSSELL, W. T. (1931). *An Introduction to Medical Statistics.* King & Son, London.

EXAMPLE 1.

Showing arrangement of experimental data into a frequency distribution.

Wing lengths of 93 *Anopheles culicifacies* (Rajindar Pal, 1945).

EXPERIMENTAL DATA (MM.).

2·50	2·56	2·62	2·37	2·56
2·43	2·50	2·56	2·56	2·75
2·75	2·81	2·50	2·37	2·93
2·68	2·43	2·59	2·62	2·68
2·68	2·69	2·56	2·68	3·12
2·75	2·75	2·56	2·50	2·87
2·81	2·50	2·43	2·50	3·00
2·75	2·81	2·87	2·43	3·00
2·81	2·50	2·50	2·62	2·81
2·62	2·50	2·25	2·62	2·93
2·50	2·37	2·75	2·62	3·25
2·75	2·56	2·37	2·18	2·81
2·68	2·37	2·43	2·37	2·31
2·68	2·75	2·31	2·31	...
2·75	2·25	2·12	2·43	...
2·50	2·62	2·43	2·81	...
2·62	2·62	2·25	2·50	...
2·62	2·56	2·31	2·68	...
2·81	2·50	2·25	2·43	...
2·31	2·62	2·50	2·81	...

FREQUENCY DISTRIBUTION.

Number of group.	'Character': Wing lengths.	'Number of individuals': Frequency.
1	2·05	1
2	2·15	1
3	2·25–	9
4	2·35–	14
5	2·45–	14
6	2·55–	20
7	2·65–	8
8	2·75–	18
9	2·85–	4
10	2·95–	2
11	3·05–	1
12	3·15–	0
13	3·25–	1
TOTAL ...	...	93

Method of arranging experimental data into a frequency distribution.

The crude data above give the figures (mean of the two wings) for each specimen of *A. culicifacies*, in the order in which they are recorded. These results are a mere 'jumble of figures', and leave no impression on the mind of the reader, except perhaps of the range of these figures. The highest and the lowest figures in this series are seen to be 2·12 mm. and 3·25 mm., and it is clear that 13 groups can be made of the entire range keeping a sufficiently small group interval of 0·10 mm.

EXAMPLE

Calculation of mean, median and mode of enlarged

(A) Apex-umbilicus measurements. (B) Apex-median

A

APEX-UMBILICUS MEASUREMENTS.

Size (1)	Frequency (2)	(1) · (2)	Running frequency, Total.
—10	1	— 10	1
— 9	0	0	1
— 8	0	0	1
— 7	1	— 7	2
— 6	1	— 6	3
— 5	5	— 25	8
— 4	3	— 12	11
— 3	5	— 15	16
— 2	1	— 2	17
— 1	0	0	17
0	10	0	27
+ 1	5	+ 5	32
+ 2	6	+ 12	38
+ 3	16	+ 48	54
+ 4	26	+ 104	80
+ 5	40	+ 200	120
+ 6	41	+ 246	161
+ 7	41	+ 287	202
+ 8	47	+ 376	249
+ 9	67	+ 603	316
+10	44	+ 440	360
+11	39	+ 429	399
+12	27	+ 324	426
+13	17	+ 221	443
+14	4	+ 56	447
+15	3	+ 45	450
TOTAL ...	450	+3,396	450
		— 77	
		+3,319	

CALCULATION OF MEAN, MEDIAN AND MODE OF A-U MEASUREMENTS.

(*a*) *Mean* $= \frac{3,396}{450} =$ *7·4 cm.*

(*b*) *Median* is mean of 225th and 226th term. Both these are in the 8 cm. group where there are 47 terms of 8 cm.
So median = *8 cm.*

(*c*) *Mode* is got from the formula :
Mode = MEAN-3 (mean-median).
= 7·4—3 (—0·6).
= 7·4 + 1·8.
= *9·2 cm.*

2.

spleens of 450 *adult convicts in Andamans.*
line measurements (Covell and Baily, 1927).

B

APEX-MEDIAN LINE MEASUREMENTS.

Size (1)	Frequency (2)	(1) · (2)	Frequency running. Total.
−10	0	·0	0
− 9	0	0	0
− 8	0	0	0
− 7	1	− 7	1
− 6	1	− 6	2
− 5	1	− 5	3
− 4	1	− 4	4
− 3	1	− 3	5
− 2	3	− 6	8
− 1	0	0	8
0	14	0	22
+ 1	11	+ 22	33
+ 2	23	+ 46	56
+ 3	34	+ 102	90
+ 4	30	+ 120	120
+ 5	46	+ 240	166
+ 6	59	+ 354	225
+ 7	42	+ 294	267
+ 8	62	+ 496	329
+ 9	53	+ 477	392
+10	42	+ 420	424
+11	19	+ 209	443
+12	7	+ 84	450
+13	0	0	450
+14	0	0	450
+15	0	0	450
TOTAL ...	450	+2,864*	450
		− 31	
		+2,833	

CALCULATION OF MEAN-MEDIAN-MODE OF A-M MEASUREMENTS.

(*a*) *Mean* $= \frac{2{,}832}{450} =$ *6·3 cm.*

(*b*) *Median* is the mean of 225th and 226th term.
Here the 225th term is 6 cm., while 226th term is 7 cm. So the median is the mean of these two terms *6·5 cm.*

(*c*) *Mode* is got from the formula :
Mode = Mean-3 (mean-median).
= 6·3—3 (− 0·2).
= *6·9 cm.*

The next step is to write out in the form of a table in two columns, the first column 'Character' which in this case are the groups of wing lengths. Next, taking the first group (2·05—2·14) we go over the entire series, and see how many figures come in this group. There is only one such figure 2·12. So we put the figure 1 in the second column, 'Number of individuals' or what is technically termed 'Frequency'. Then we go to the next group interval, 2·15—2·24, and again we find only one figure 2·18. In the next group, 2·25—2·34, we find 9 figures, so we put 9 and so forth. The total of this column should be 93 which aids as a final check up.

This table is known as a 'Frequency distribution' and is of fundamental importance in statistics. From this are made all calculations and graphs.

EXAMPLE 3.

Calculation of mean and standard deviation of a simple series.

Marks obtained by ten students at an examination (Hypothetical).

DATA.		METHOD I.		METHOD II.		METHOD III.
Number of students.	Number of marks obtained.	Deviation from mean 40.	Deviation square.	Deviation from 30.	Deviation square.	(Deviation from zero)^2 or square of numbers.
1	41	+1	1	+11	121	1,681
2	43	+3	9	+13	169	1,849
3	34	−6	36	+ 4	16	1,156
4	38	−2	4	+ 8	64	1,444
5	45	+5	25	+15	225	2,025
6	37	−3	9	+ 7	49	1,369
7	44	+4	16	+14	196	1,936
8	47	+7	49	+17	289	2,209
9	40	0	0	+10	100	1,600
10	31	−9	81	+ 1	1	961
TOTALS ...	400	...	230	...	1,230	16,230

Method I : Deviation from mean 40.

Mean mark = 40.

Mean of deviation square $= \frac{230}{10} = 23.$

S. D. $= \sqrt{23} = 4{\cdot}8.$

Method II : Deviation from any other point, say 30.

$$\text{S. D.}^2 = \frac{1{,}230}{10} - (40-30)^2.$$

$$= 123 - 100 = 23.$$

S. D. $= \sqrt{23} = 4{\cdot}8.$

Method III : Deviation from 0 — (That is square of numbers).

$$S.\ D.^2 = \frac{16,230}{10} - 40^2 = 1,623 - 1,600 = 23.$$

$$\therefore\ S.\ D. = \sqrt{23} = 4{\cdot}8.$$

The standard deviation

$$= \sqrt{\left(\frac{\text{Sum of the squares of observations}}{\text{Number of observations}}\right) - (\text{Mean of the observations})^2}.$$

In other words, square root of (the mean of the squares minus the square of the mean).

EXAMPLE 4.

Calculation of the mean and standard deviation of a grouped series.

Height of 200 school children (Wood and Russell).

Height in inches. (1)	Frequency. (2)	Deviation from arbitrary mean in unit measurement. (3)	Products of Cols. (2) × (3) (4)	Products of Cols. (3) × (4) (5)
42–	1	−5	−5	25
44–	3	−4	−12	48
46–	8	−3	−24	72
48–	15	−2	−30	60
50–	33	−1	−33	33
			−104	
52–	76	0		0
54–	37	+1	+37	37
56–	16	+2	+32	64
58–	8	+3	+24	72
60–	2	+4	+8	32
62–64	1	+5	+5	25
			+106	
SUM ...	200	...	+2	468

1. Calculation of mean (1) The arbitrary mean is 0.

(2) The mean deviation from the arbitrary mean is

$$+\frac{2}{200} = 0{\cdot}01.$$

(3) The mid-point of the group in which we placed our arbitrary mean is 53·0. As the actual class interval is 2 and not 1 as in the series in (3), the value of the mean deviation 0·01 must be multiplied by 2 to bring it to the proper dimensions of the original series in column (1)

(4) Hence the actual mean height $= 53 + (0{\cdot}01 \times 2)$
$= 53{\cdot}02.$

2. Calculation of standard deviation

This may be first worked out in working units and then transformed into actual measurements as in the above.

$$(\text{S. D. in working units}) = \sqrt{\frac{468}{200} - (0{\cdot}01)^2} = \sqrt{2{\cdot}3400 - 0{\cdot}0001}$$
$$= \sqrt{2{\cdot}3399} = 1{\cdot}5297$$

As the unit of grouping in column (1) is 2 and not 1 as in column (3) this must be multiplied by 2.

$\therefore$ Actual standard deviation $= 1{\cdot}5297 \times 2$
$= 3{\cdot}0594.$

EXAMPLE 5.

Correlation table.

Numbers of husbands and wives who died at various ages: Data from gravestone inscriptions of 876 couples in England. (*Biometrica.*)

Age of husband (years).	Age of wife (years).									Total.
	15–	25–	35–	45–	55–	65–	75–	85–	95–	
25–	2	4	4	5	...	5	2	...	...	22
35–	...	7	5	4	11	12	7	1	1	48
45–	...	4	9	7	11	17	28	6	...	82
55–	...	6	13	17	33	35	32	9	1	146
65–	1	11	23	18	45	74	64	19	3	258
75–	3	6	14	17	27	71	81	28	1	248
84–	...	1	3	7	9	13	21	12	...	66
95–	...	...	...	1	2	...	2	...	1	6
Total	6	39	71	76	138	227	237	75	7	876

The clumping of figures in the middle of the table is characteristic of the two variables exhibiting correlation. If a similar table is drawn for the heights of couples no such clumping will be noticeable, and figures will be equally distributed more or less throughout the table.

EXAMPLE 6.

Correlation between death rates and spleen rates in nine districts in Mauritius (Sir Ronald Ross, 1911).

District.	Death rate (D).	Spleen rate (S).	D^2	S^2	$D \times S$
1	36·6	35·6	1,339·56	1,267·36	1,302·96
2	46·1	45·7	2,125·21	2,088·49	2,106·77
3	39·7	27·6	1,576·09	761·76	2,658·48
4	42·4	62·7	1,797·76	3,931·29	1,636·64
5	38·6	42·4	1,489·96	1,797·76	717·50
6	32·5	23·0	1,056·25	529·00	2,572·44
7	44·2	58·2	1,953·64	3,387·24	348·32
8	31·1	11·2	967·21	125·44	456·17
9	31·9	14·3	1,017·61	204·49	...
TOTAL ...	343·1	320·7	13,323·29	14,092·83	12,895·00
Mean ...	38·12	35·63	1,480·36	1,565·86	1,432·77

Standard deviation of D $= \sqrt{1{,}480 \cdot 36 - 38 \cdot 12^2} = \sqrt{27 \cdot 23} = 5 \cdot 22.$

Standard deviation of S $= \sqrt{1{,}565 \cdot 86 - 35 \cdot 63^2} = \sqrt{296 \cdot 36} = 17 \cdot 21.$

$$\text{Coefficient of correlation} = \frac{\text{Mean sum of products} - \text{Products of means}}{\text{Product of standard deviation of D and S}}$$

$$= \frac{1{,}432 \cdot 77 - (38 \cdot 12 \times 35 \cdot 63)}{5 \cdot 22 \times 17 \cdot 21} = \frac{74 \cdot 55}{89 \cdot 84} = +\,0 \cdot 84.$$

EXAMPLE 7.

Regression coefficient between spleen rates and death rates (data from Example 6).

I. The regression coefficient of spleen rate in terms of death rates, i.e., the average change in spleen rate for a unit change in death rate is given by $\frac{\text{Standard deviation of spleen rate}}{\text{Standard deviation of death rate}} \times$ correlation coefficient of S. R. and D. R. $= \frac{17 \cdot 21}{5 \cdot 22} \times 0 \cdot 84 = 2 \cdot 77.$

II. The regression coefficient of death rate in terms of spleen rates, i.e., the average change in death rate for a unit change in spleen rate is given by $\frac{\text{Standard deviation of death rate}}{\text{Standard deviation of spleen rate}} \times$ correlation coefficient of S. R. and D. R. $= \frac{5{\cdot}22}{17{\cdot}21} \times 0{\cdot}84 = 0{\cdot}25$.

III. *The regression equation:* Given a particular spleen rate we may calculate the death rate thus:—

Death rate—mean death rate

= Regression coefficient (spleen rate—mean spleen rate).

If D represents death rate and S represents spleen rate,

$D - 38{\cdot}1 = 0{\cdot}25\ (S - 35{\cdot}6)$

The regression equation is $D = 0{\cdot}25\ S + 29{\cdot}2$.

Indian Journal of Malariology, **2**, 3, September 1948.

CONTROL OF RURAL MALARIA WITH D.D.T. INDOOR RESIDUAL SPRAYING IN KANARA AND DHARWAR DISTRICTS, BOMBAY PROVINCE: SECOND YEAR'S RESULTS, 1947-48.*

BY

D. K. VISWANATHAN,

AND

T. RAMACHANDRA RAO.

(*Malaria Organization, Bombay Province.*)

[October 16, 1948.]

THE scheme of extensive rural malaria control in Dharwar and Kanara districts described in a previous paper (Viswanathan and Ramachandra Rao, 1947) has been in operation for yet another year since July 1947, and the nature of the work and further benefits accrued during the second year have been recorded in this paper.

EPIDEMIOLOGY.

The epidemiology of malaria in Kanara District has on many previous occasions been described at great length. Except for a narrow coastal strip on the West Coast, the entire forest-clad district lies on the 2,000 feet plateau and has been intensely malarious for centuries with gradually declining population. The vector species, *A. fluviatilis*, principally rests outdoors but those which stay indoors prefer human houses to cattlesheds for daytime resting. It is highly anthropophilic and over a whole season, prior to control, as high a natural infection rate as 10 per cent has been met with. In Dharwar District, also on the 2,000 feet

* The authors gratefully acknowledge the assistance received from the members of the staff of the organization in carrying out this project. Particular mention should be made of Capts. M. R. Damdhere, H. F. Daroga, S. R. Kulkarni, M. R. Juneja and B. S. Raghavan, the Medical Officers in charge of the five Units. The results achieved are mainly due to their field work and the authors, having been in technical direction of the project, have the privilege of recording the same on their behalf.

plateau, except in the westernmost talukas where conditions are similar to Kanara District, *A. culicifacies* is the vector which prefers to rest during day far more in cattlesheds than in houses. In the latter areas malaria was of moderate to high endemicity and subject to considerable fluctuations.

EXTENSION OF THE SCHEME.

The scheme as originally sanctioned included within its scope only two districts, viz. Dharwar and Kanara. During the course of first year's operations there was a persistent clamour for its extension to two adjoining talukas of Belgaum District, viz. Belgaum and Khanapur, in which topography, climate and epidemiology were almost the same as in the original scheme area. Accordingly, selected villages in Khanapur and Belgaum talukas were included within the scope of the scheme since July 1947.

The marked reduction in malaria resulting from the first season's spraying received wide and spontaneous recognition among the rural folk and applications were received from a number of villages which had not previously been included because of inadequate data. Such villages were invariably surveyed and were included in the scheme provided they satisfied two criteria, viz. (1) having a spleen rate of over 10 per cent and (2) having a population of at least 200 in Dharwar District and at least 100 in Kanara.

The population limits set above are not altogether arbitrary. The time required for transit and supervision, if work were extended to the villages with smaller population which are also usually widely scattered, could not be found within the limitations of the staff and transport facilities sanctioned for the scheme. Besides, nearly 80 per cent of the total population in the highly malarious tracts has already been included in the scheme.

In Table I are summarized data as regards the population directly protected by the scheme at the close of the second year's work.

With further knowledge of the epidemiology of malaria in the coastal talukas of Kanara District, gained during the first year's work, it was found necessary that some of the villages should be sprayed immediately after the close of the monsoon. Therefore, several villages in the zone which were sprayed during the previous year only between December and June were given an advance spraying in October and November. In these villages it was found during the first year that as in Yellapur Taluka and Supa Petha breeding of *A. fluviatilis* is established soon after the close of the monsoon.

STAFF AND ORGANIZATIONAL CHANGES.

Consequent on the extension of the scheme both in the area and the period of the spraying season as stated above, a few changes became necessary in the distribution of staff and the allocation of areas to the five units. Owing to paucity of suitably trained subordinate medical personnel to fill the posts of Assistant Medical Officers, a new class of posts designated Malaria Supervisors was created and was filled by adequately trained graduates in science. The number and period of employment of the field workers (havildars and sepoys) were also

slightly adjusted to meet the new set-up, leading to a slight overall reduction in the total labour costs. The salient features of the modified organization were as follows :—

Number of units	5	
Medical Officers in charge of units ...	5	
Assistant Medical Officers	4	
Malaria Supervisors	5	
Havildars (Senior Malaria Field Workers) ...	22	From December to June.
	26	July to September.
	34	In October and November only.
Sepoys (Malaria Field Workers)	100	From December to June.
	120	July to September.
	160	October and November.
Drivers	5	
Cleaners	5	
Head-clerk	1	
Clerks	9	

Jurisdictions (by talukas) of the units were as follows :—

Unit.	July–November.		December–June.
No. 1, Headquarters Karwar	Kalghatgi, Haliyal	I and II rounds of spray.	Karwar (all rounds).
	Khanapur, Belgaum	I round	Ankola (all rounds).
	Supa	I round	Supa (3 more rounds).
Advance spraying in selected villages of Karwar, Ankola, Kumta, Honavar and Bhatkal Petha in October and November.			
No. 2, Headquarters Dharwar	Dharwar, Gadag, Mundargi, Ron	All rounds	No spraying.
	Kalghatgi, Haliyal	III round	Assessment of results in whole of Dharwar District.
	Khanapur, Belgaum	II and III rounds	...

Unit.	July–November.		December–June.	
No. 3, Headquarters Haveri and Siddapur.	Haveri Bankapur Hubli	All rounds	Siddapur (all rounds).	
No. 4, Headquarters Ranebennur and Honnavar.	Ranebennur Kod	All rounds	Honnavar Bhatkal	All rounds.
No. 5, Headquarters Sirsi	Sirsi (rice tract). Mundgod Yellapur Hangal	All rounds	Sirsi (garden tract). Yellapur Kumta	All rounds.

Advance spraying in selected villages of Siddapur and Sirsi (garden tract) talukas (October and November only).

Two or three insect collectors according to the size of the unit were posted to each unit.

A feature of this year's work was that the spraying in Dharwar Town was done by Dharwar Borough Municipality under the supervision of and with the materials supplied free of cost by this Department.

SPRAYING MATERIAL, TECHNIQUE AND COSTS.

There was no change from what was previously reported in the spraying technique, in the dosage of application (56 mg. per square foot), frequency of spraying (once in 2 months against *fluviatilis* and once in 6 weeks against *culicifacies*) or in the structures sprayed (houses only in *fluviatilis* areas and all structures including cattlesheds in *culicifacies* areas). The D.D.T.-M.K.E. soap emulsion continued to be the main material used. But purely as an experimental measure a few talukas of Dharwar District and the Khanapur Taluka of Belgaum District were sprayed for one round only with a proprietary brand of D.D.T. emulsion. Owing to its prohibitive cost at 5 per cent final strength, it was used at 1 per cent and 2½ per cent resulting in the low dosages of 11 or 28 milligrammes per square foot respectively. There was a considerable degree of public criticism against the use of this product and it had to be given up and the usual formulation had to be sprayed for the next round well ahead of the scheduled period.

The total quantities of D.D.T. actually used for the second year (July 1947 to June 1948) by the several units were :—

	D.D.T. (Tech.). Lbs.	Proprietary brand emulsion 25 per cent D.D.T. Gallons.	Suspension powder 50 per cent. Lbs.
Unit No. 1	11,905	368	...
Unit No. 2	9,813	127	...
Unit No. 3	12,109	157	81
Unit No. 4	11,630	209	33
Unit No. 5	11,105	28	...
Dharwar Municipality ...	4,648	156	...
TOTAL ...	61,210	1,045	114

The budget of the scheme was slightly augmented because of the extension of the spraying to parts of Belgaum District. The actual total expenditure during the twelve months (July 1947 to June 1948) was :—

LABOUR AND SUPERVISION.

	Rs.	A.	P.
Pay of officers	18,818	2	0
Pay of establishment	62,766	12	0
Allowances (dearness, travelling, etc.) ...	87,188	15	0
Contingent charges.			
D.D.T., M.K.E., and other charges ...	3,28,295	6	4
TOTAL ...	4,97,069	3	4

Stirrup pumps fitted with oil-resisting long hose, brass lance, and nozzle delivering about 600 c.c. per minute in a cone-shaped spray continued to be used, each pump being operated by two men.

RESULTS.

DENSITIES OF ANOPHELES ADULTS.

The comparative densities of all anophelines and of *culicifacies* and *fluviatilis* in sprayed and unsprayed villages of Kanara and Dharwar districts are presented

in Tables II and III and Charts 1, 2, 3 and 4. The densities are, as before, reduced to average numbers collected per 10 man-hours based on timed hand collections made by trained insect collectors with the aid of suction tubes. The prevalence of adults in sprayed villages was very low, particularly of the vector species. Compared to the previous year, the prevalence of the vector species in the unsprayed villages was very much greater in the case of *culicifacies* during the year 1947-48. In the houses and mixed dwellings of Dharwar District the average density per 10 man-hours in unsprayed structures reached such a high figure as 90 in November and including unsprayed cattlesheds the figure was 105. The assumed critical density for effective transmission by this species, viz. 50 per 10 man-hours, was exceeded throughout from July to November (with a slight inexplicable notch in August). The density of *A. culicifacies* in the sprayed houses and mixed dwellings was however very low, the highest figure being 6·04 per 10 man-hours in August and including sprayed cattlesheds it was only 10 per 10 man-hours. The prevalence of *A. fluviatilis* in Kanara was very much lower than in the previous year both in the sprayed and unsprayed areas. The highest density recorded in any month in unsprayed houses was 3·9 per 10 man-hours just reaching our assumed critical density for this species. In sprayed houses it was practically non-existent except for a few specimens in July and August. Correspondingly there was a noticeable reduction in the numbers of *fluviatilis* collected in cattlesheds in sprayed villages. It may here be stated that cattlesheds are not sprayed in Kanara District. We cannot expect the spraying operations in the greater part of the district to affect the density of the vector population in non-sprayed villages which are well beyond the range of flight from the sprayed villages. Data collected in future years are likely to throw further light on the matter.

SPLEEN AND PARASITE RATES.

Kanara District.—The spleen and parasite rates (age group 2–9) in unsprayed and sprayed villages respectively in Kanara District are presented in Tables IV and V. Wherever they were available, the spleen rates of the year 1946-47 are also given to facilitate comparison. The reductions in spleen rates in the sprayed villages have been clear and consistent. The cumulative spleen rates of all the sprayed and unsprayed villages which were surveyed in Kanara District during 1947-48 were 11·6 and 47·1 respectively. During the survey made in 1947-48 both in sprayed and unsprayed villages a very much larger number has been included than in 1946-47. During the latter year spleen rates for sprayed and unsprayed villages were 14·4 and 72·2 per cent respectively. These data related to the five talukas of Sirsi, Siddapur, Yellapur, Haliyal and Mundgod. Similar data in 1947-48 restricted to these talukas are 8·3 per cent in sprayed and 59·6 per cent in unsprayed villages.

The cumulative parasite rates in 1947-48 were 19·5 per cent in the unsprayed and 2·7 per cent in the sprayed villages. Similar figures for 1946-47 were 14·6 per cent (unsprayed) and 3·8 per cent (sprayed).

The spleen and parasite rates of a few places in which regular periodical records have been made in previous years are given below and also in Chart 5.

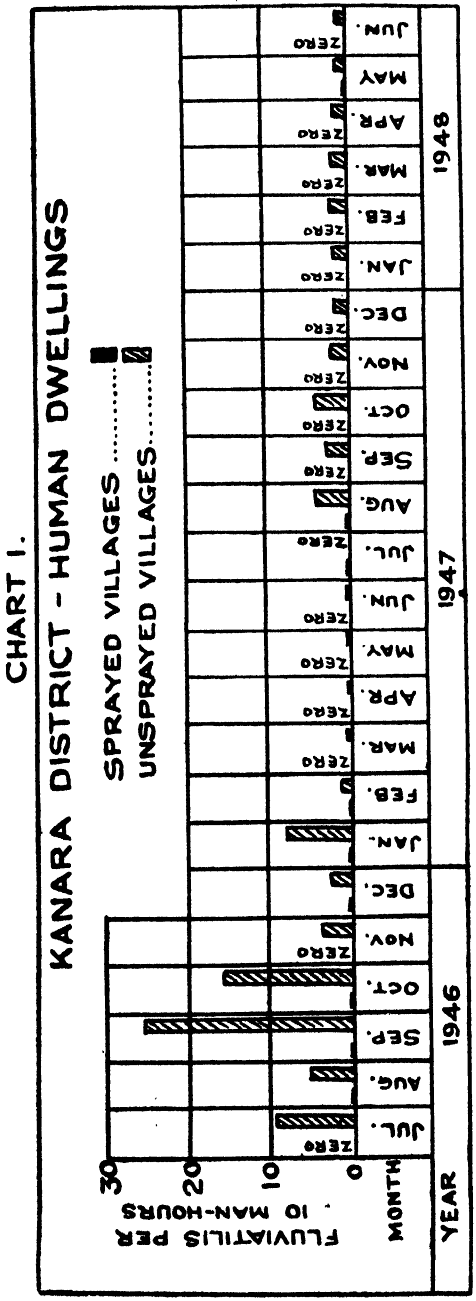


CHART I.
KANARA DISTRICT - HUMAN DWELLINGS
SPRAYED VILLAGES
UNSPRAYED VILLAGES
FLUVIATILIS PER 10 MAN-HOURS
MONTH
YEAR
JUL. AUG. SEP. OCT. NOV. DEC.
1946
JAN. FEB. MAR. APR. MAY. JUN. JUL. AUG. SEP. OCT. NOV. DEC.
1947
JAN. FEB. MAR. APR. MAY. JUN.
1948
ZERO
0
10
20
30

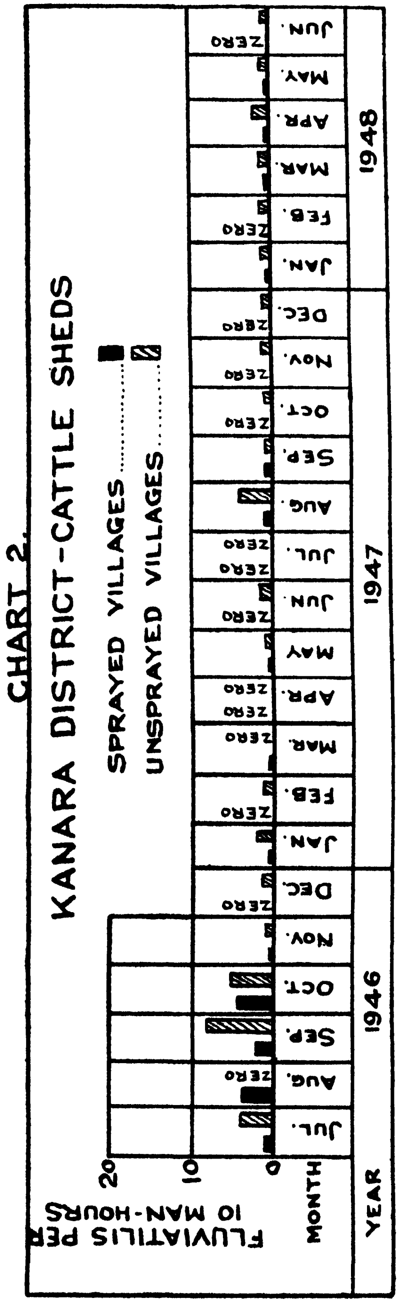


CHART 2.
KANARA DISTRICT-CATTLE SHEDS
SPRAYED VILLAGES
UNSPRAYED VILLAGES
FLUVIATILIS PER 10 MAN-HOURS
MONTH
YEAR
JUL. AUG. SEP. OCT. NOV. DEC.
1946
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC.
1947
JAN. FEB. MAR. APR. MAY. JUN.
1948
ZERO
0
10
20

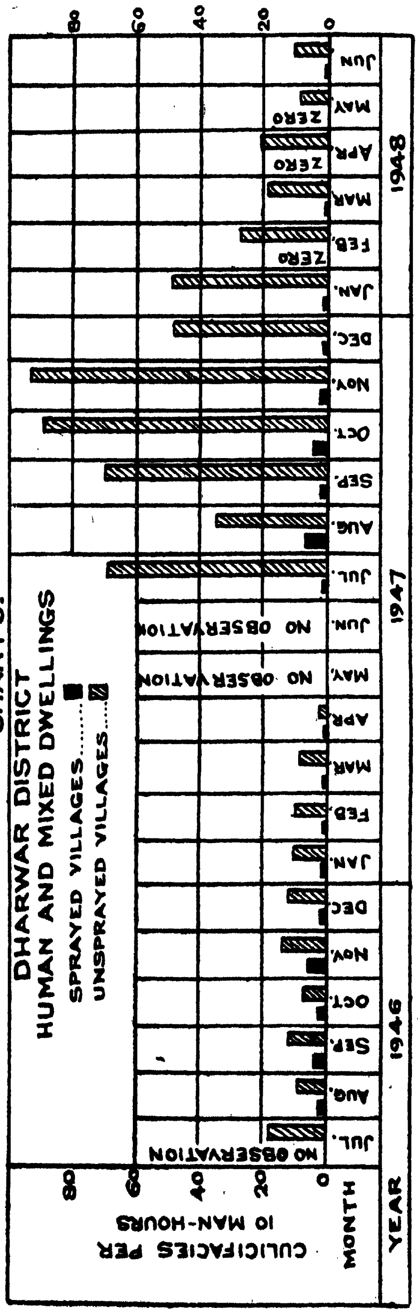


CHART 3.
DHARWAR DISTRICT
HUMAN AND MIXED DWELLINGS
SPRAYED VILLAGES........
UNSPRAYED VILLAGES.....
CULICIFACIES PER 10 MAN-HOURS
80
60
40
20
0
MONTH
YEAR
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUN.
1946
1947
1948
NO OBSERVATION
ZERO

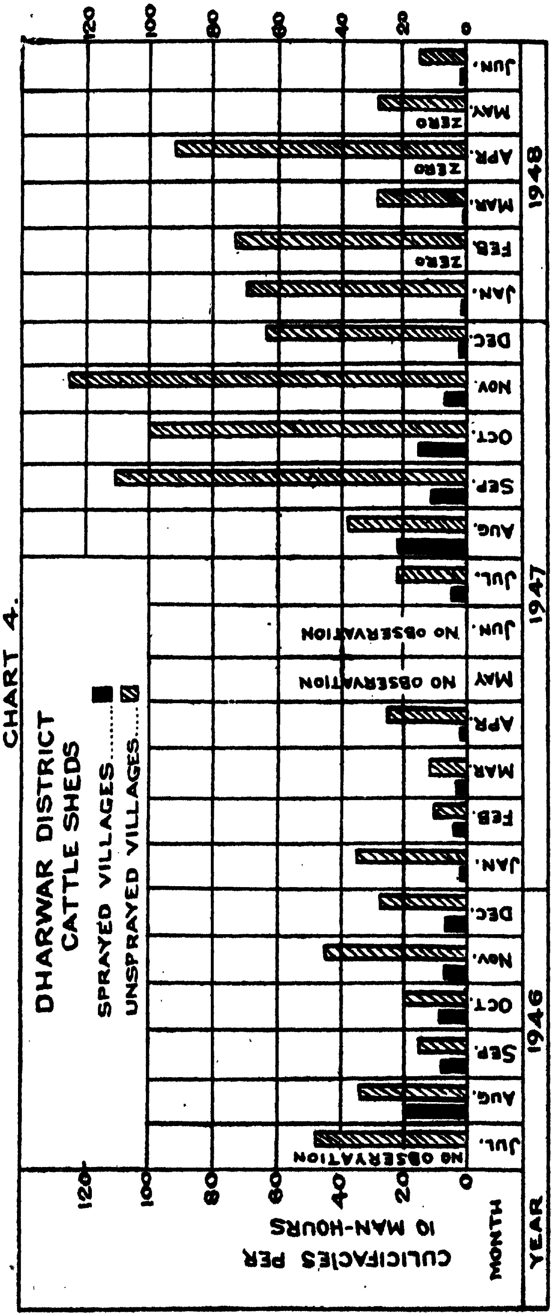


CHART 4.
DHARWAR DISTRICT
CATTLE SHEDS
SPRAYED VILLAGES........
UNSPRAYED VILLAGES.....
CULICIFACIES PER 10 MAN-HOURS
120
100
80
60
40
20
0
MONTH
YEAR
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUN.
1946
1947
1948
NO OBSERVATION
ZERO

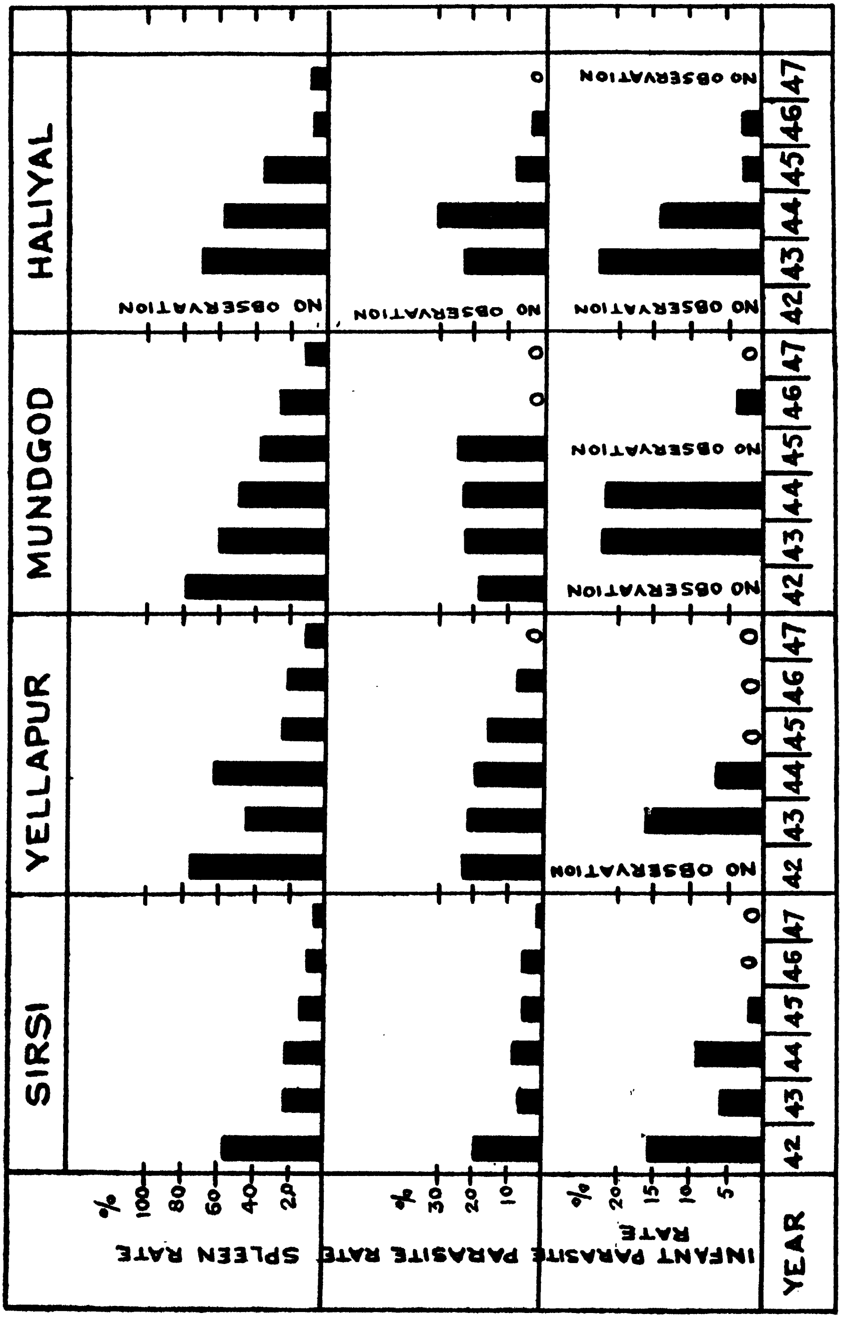

HALIYAL
MUNDGOD
YELLAPUR
SIRSI
SPLEEN RATE
PARASITE RATE
INFANT PARASITE RATE
YEAR
NO OBSERVATION
42
43
44
45
46
47

CHART 5.

	1942.	1943.	1944.	1945.	1946.	1947.
			Spleen rate per cent.			
Sirsi Town	50	20	20	12	8	4
Yellapur Town	70	45	58	24	19	9
Mundgod Town	75	58	45	35	25	11
Haliyal Town	...	67	56	34	7	9
			Parasite rate per cent.			
Sirsi Town	18	6	8	5	5	1
Yellapur Town	22	20	18	15	5	0
Mundgod Town	18	22	22	23	0	0
Haliyal Town	...	20	29	7	3	0

In all the villages listed above some kind of malaria control or other was in progress from 1943 but D.D.T. was started in 1946 and since then the reduction in indices is far more marked.

Dharwar District.—The spleen and parasite rates in unsprayed and sprayed villages of Dharwar District are given in Tables VI and VII respectively and the 1946-47 spleen rates wherever available are also given for purposes of comparison. As in the previous year, the number of unsprayed malarious villages was not adequate for purposes of comparison, most of the endemic villages having been taken up for control. The cumulative spleen rate in 1947-48 was 25·1 per cent in unsprayed villages and 10·6 per cent in sprayed villages as compared with 28·3 and 19·7 per cent respectively in 1946-47.

Comparative data of spleen rate in a few sprayed places where they are being recorded annually since 1945-46 are as follows :—

	1945-46 (per cent).	1946-47 (per cent).	1947-48 (per cent).
Dharwar Taluka.			
Alnavar	40·0	30·8	8·3
Kelgeri	69·5	39·6	20·6
Mugad	44·1	32·9	9·4
Navlur	71·0	27·4	9·8
Mummigatti	42·8	14·3	4·9
Tegur	68·6	44·8	21·3
Narendra	38·8	14·5	7·6

	1945-46 (per cent).	1946-47 (per cent).	1947-48 (per cent).
Kalghatgi Taluka.			
Kalghatgi	57·4	8·7	6·9
Dastikop	41·5	13·5	11·5
Begur	36·7	16·3	7·6
Machapur	87·5	19·0	8·3
Madkihonnali	47·8	16·6	9·6
Ramanhal	26·3	24·2	13·1
Hubli Taluka.			
Amargol	46·9	20·2	10·0
Unkal	45·1	26·9	5·7
Gokul	35·0	12·8	3·2
Adargunchi	8·8	5·0	4·2
Sherwad	7·5	8·3	3·3
Ranebennur Taluka.			
Halgeri	27·3	8·0	3·9
Itagi	45·0	22·4	0·0
Karur	21·3	10·0	2·6
Motebennur	27·0	17·0	3·8
Ranebennur	11·0	1·2	3·6
Kod Taluka.			
Rattihalli	19·6	6·0	3·3
Masur	53·2	30·0	19·5
Hirekerur	48·6	20·8	8·6
Chikkerur	39·7	16·0	7·5
Bankapur (Shiggaon) Taluka.			
Shiggaon	13·0	20·8	12·1
Mundargi Petha.			
Dambal	61·9	14·0	19·8
Mundargi	13·8	17·9	9·7

	1945-46 (per cent).	1946-47 (per cent).	1947-48 (per cent).
Haveri Taluka.			
Haveri	23·1	8·5	3·5
Gadag Taluka.			
Advisomapur	34·7	19·4	13·8
Asundi	29·4	19·5	11·0
Chikop	68·7	47·2	25·0
Hirekop	81·8	43·9	21·8
Malasamudra	46·4	28·8	15·7
Papanashi	61·8	39·6	13·7
Nagasamudra	50·0	31·0	26·7
CUMULATIVE ...	39·7	20·3	10·6

The parasite rates were 5·2 per cent in the unsprayed villages and 0·9 per cent in sprayed villages in 1947-48 as compared with 7·5 per cent and 4·3 per cent respectively.

Belgaum District.—Comparative spleen rates in the unsprayed and sprayed villages of Khanapur Taluka are given in Table VIII. D.D.T. spraying was commenced in this taluka only in July 1947 and has hence been in progress during one season only. Even so, the spleen rates show a substantial reduction almost by 50 per cent, the spleen rate at the end of the year 1947-48 being only 19·4 per cent in sprayed villages as against a spleen rate of 40·8 per cent in the same area prior to spraying. The rates in the unsprayed villages too showed a slight fall from 40·8 per cent to 33·5 per cent. The parasite rate in 1947-48 was 13·6 per cent in the unsprayed villages and only 2·9 per cent in the sprayed villages. These data were not compiled in the previous year.

INFANT PARASITE RATE.

Tables IX and X show the infant parasite rates in sprayed and unsprayed villages respectively in Kanara District. In the sprayed villages the infant parasite rate was 0·4 per cent while last year it was 0·8 per cent. In the unsprayed villages the rates were 20·0 per cent this year as compared with 13·3 per cent during the previous year.

DISPENSARY STATISTICS.

In Table XI and Charts 6 and 7 are presented the yearly totals of the number of malaria cases treated in the several dispensaries in the two districts. There is a further reduction in 1947 than in 1946.

CHART 7.
DHARWAR DISTRICT
(8 DISPENSARIES)

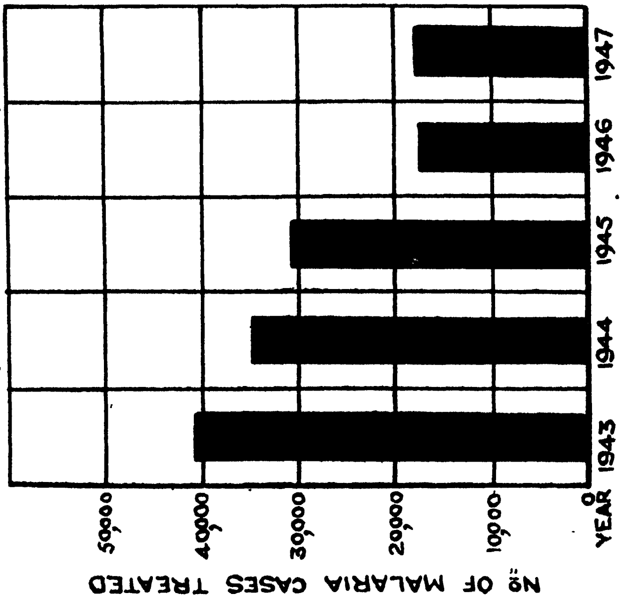
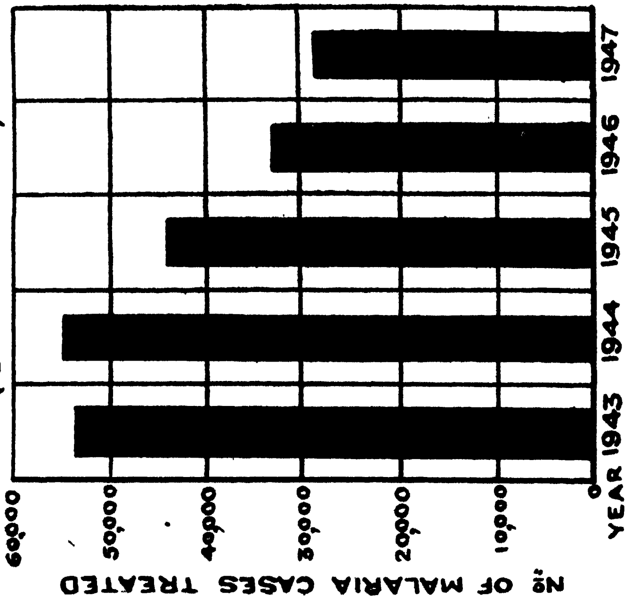


CHART 6.
KANARA DISTRICT
(12 DISPENSARIES)



MORTALITY STATISTICS.

In Table XII are presented yearly mortality statistics from 1936 to 1947 with the quinquennial averages for 1936 to 1940 and 1941 to 1945 under the heads all causes, fevers, malaria and diarrhœa and dysentery for the province of Bombay as a whole and for Dharwar and Kanara districts separately. The provincial figures show a progressively increasing number of deaths under every head in keeping with the general increase in population. There had, however, been a definite fall in the year 1946 in the total mortality as well as under each individual cause. But in 1947 mortality has swung back to the rising trend. In Kanara District, mortality figures show a progressive decline due to the gradual reduction in population from year to year. But deaths due to fevers and malaria show a much steeper decline in 1946 and 1947 than in the past. The average malaria deaths in 1936–40 was 947 and in 1941–45 it was 895. In 1946, it was only 588 and in 1947 too it was only 604, the lowest figures ever reached. At least 300 deaths from malaria may be deemed as having been saved every year. Diarrhœa and dysentery have accounted for relatively fewer deaths in 1946 throughout the province and Kanara has shared in that experience. In 1947, there is a slight increase in mortality due to this cause as compared with the average for 1941–45. In Dharwar District, deaths under malaria and diarrhœa and dysentery show a very considerable decline in 1946 and 1947. Even comparing with the favourable quinquennial average for 1936–40, there has been a reduction in malaria deaths to the extent of 300 to 400 in each of the two years 1946 and 1947. If compared with the average for 1941–45, the reduction is more than 2,000 each year. Likewise under diarrhœa and dysentery too there is a reduction to the extent of 400 to 600 deaths each year. The malaria mortality is reduced by 20 per cent and dysentery mortality by about 40 to 60 per cent.

DISCUSSION.

The second year's record of the largest rural malaria control project undertaken in India harnessing the war-time discovery and use of D.D.T. on a mass scale has fully confirmed the earlier promising results.

Only three specimens of *A. fluviatilis* were collected from sprayed houses in Kanara District during the entire 12 months' period after a search for more than 2,000 man-hours. One hopes that this is evidence of eventual eradication of the species by efforts solely restricted to indoor residual spray. That no such false sense of security can however be engendered is shown by the fact that as many as 20 specimens were caught from cattlesheds in the sprayed villages in a search for about 900 hours. It is true that cattlesheds are not sprayed in Kanara District but the presence of a species with such a highly anthropophilic index as *fluviatilis* in cattlesheds is a definite indication of the survival of human feeders and hence with the present dosage and frequency of application, viz. 56 mg. per square foot and once in 2 months, eradication of this species cannot be achieved even after continued indoor residual spray over a period of years if not supplemented with antilarval methods. Whether however such eradication is possible solely with indoor residual spray if the entire district is included in the spray leaving no islands whatever it is not possible to say. The previously recorded outdoor daytime resting habits of this species do not lend support to such a

possibility. The programme may therefore have to be continued every year to maintain progress.

In the unsprayed villages of Kanara District only about 350 specimens of *A. fluviatilis* were caught during a search for a little less than 2,000 man-hours or about 1·75 per 10 man-hours. This is far less than our assumed critical density of 4 per 10 man-hours for this species. The lower catch indicates a lesser prevalence of this species during the year rather than any beneficial effect of the spraying programme in the major part of the district being reflected in the unsprayed areas as well. In the first place such a concept is not in consonance with malaria being a locally transmitted disease within the effective range of flight of the vector species. Secondly, catches made during the recent and earlier months of the third year show a very high prevalence in unsprayed villages. During the year under report the reduction in *fluviatilis* in sprayed villages is about 99 per cent as compared with 90 per cent in the previous year.

In Dharwar District where both cattlesheds and houses are sprayed, the density of *culicifacies* was about a little over 50 per 10 man-hours in the unsprayed villages taking the whole year into consideration while in the sprayed villages it was only a little over 3 per 10 man-hours. The total reduction was well over 90 per cent as compared with 70 to 80 per cent in the previous year. During the malaria season (and the spraying season) the reduction was even more. In the case of *culicifacies*, the same dosage of D.D.T. as indoor residual spray at an interval of 6 weeks helps only to keep the density below the critical threshold and eradication is entirely out of question.

On the whole the method has during the second year in succession shown to be of great utility against malaria transmitted by *fluviatilis* and *culicifacies*. Both have widely different habits but both transmit malaria indoors predominantly and hence both species are vulnerable to D.D.T. as indoor residual spray. It is therefore permissible to assume as was done during the previous year that D.D.T. indoor residual spray will be effective in control of rural malaria transmitted by any anopheline irrespective of its resting habits so long as it enters indoors during the night for a feed of blood. There is no evidence with respect to these two species to show that they are stimulated to fly away from houses and later trained to take the bee line to the host of predilection and shoot out into the wild after the blood meal without ever hovering on the walls either before or after the feed.

The spleen, parasite and infant parasite rates all show continued reduction. In Kanara District as low a spleen rate as 11·6 per cent has been reached while in the comparison villages they are still nearly 50 per cent. In 5 talukas surveyed both during the last and the present years the comparative spleen rates are 14·4 per cent (1946) and 8·5 per cent (1947) in the sprayed villages. In the unsprayed villages they were 72·2 per cent (1946) and 59·6 per cent (1947). In Dharwar District the spleen rate has still further dropped from 19·7 per cent in 1946 to 10·6 per cent in 1947. Infant parasite rates have reached the zero level in both districts and childhood parasite rates are extremely low.

The dispensary figures give food for thought. One may say that these figures reveal a 50 to 55 per cent reduction from the pre-spraying period. But what one wonders is why these figures should not show an even greater reduction

than one would expect from (1) the public report that malaria has been reduced by 80–90 per cent, (2) the vastly reduced prevalence of vector species of anophelines, and (3) the great reduction in spleen, parasite and infant parasite rates. The dispensary figures are no doubt not based on microscopic diagnosis. In the tropics, even in areas which are non-endemic for malaria judging from a spleen census, dispensaries record a substantial proportion of the daily out-patient cases as due to malaria. In our experience 10 per cent of the total admissions being recorded as due to malaria as a result of out-patient clinical diagnosis, is consistent with an almost entire absence of local transmission judged by any of the other indices used in malariometry. It is therefore urged that the Indian Research Fund Association should undertake a special study by its Clinical Research Advisory Committee on the degree of accuracy of out-patient diagnosis of malaria in dispensaries selected in different parts of the country at random but representing different known levels of malarial endemicity. In the 19 dispensaries in the two districts the figures that are presented show a reduction of more than 50,000 cases of malaria. These dispensaries serve at best a sixth of the total population in the scheme area. Hence, if the same degree of reduction is assumed in the entire area there are actually about 300,000 cases of malaria less every year after the D.D.T. spraying was introduced. Towards this task a sum of 5 lakhs of rupees is spent or about a rupee and eleven annas per case of malaria saved. The economic gain that has been secured is thus only too patent not to speak of the humanitarian aspect.

The mortality statistics offer yet another evidence of the benefits of the scheme. In Kanara, there is a reduction in malaria mortality by 30 per cent involving about 300 less deaths due to this cause during either of the last two years. In Dharwar, the reduction is at least 20 per cent allowing for fluctuations. There have been at least 300 to 400 deaths less in 1946 and again in 1947 due to malaria. Under diarrhœa and dysentery there is a reduction in deaths to the extent of 400 to 600 per year or about 40 to 60 per cent. No such decrease under this head is seen in Kanara. In the latter district, cattlesheds are not sprayed while in Dharwar they are. Is the fly population considerably affected due to spraying cattlesheds and are deaths due to diarrhœa and dysentery less on that account? It would seem desirable to keep a measure of fly densities in sprayed and unsprayed villages in Kanara and Dharwar districts with a view to throw further light on this problem. This is an additional collateral effect due to D.D.T. spray, an experience which has been recorded by practically every worker in the North and South Americas, as reported during the Session of the Fourth International Congress on Malaria held in Washington, D.C., U.S.A., in May 1948.

A word of caution should however be uttered. The fallacy in diagnosis referred to under dispensary statistics applies with greater force in the registration of mortality. Non-medical village officers record deaths and their causes. Only if the reductions now recorded are maintained over a period of years, can they be claimed with any validity as due to the special efforts now undertaken?

In the entire scheme area there has not been a single case of human plague for the second year in succession.

The efficacy of D.D.T. indoor residual spray against all insects transmitting disease brings the indoor spray to the rôle of *premises sanitation*, a phrase coined,

we believe, by Dr. Fred. L. Soper of the Rockefeller Foundation. Soper (1948) has dealt at length with the conflict between the concept of eradication of one species and a domestic service for disinfestation of all insects of disease carrying importance. The recent work of Aziz (1948) in eradication of malaria in Cyprus shows this method to be within the realms of possibility but it will cost eight rupees per head. The D.D.T. scheme here reported costs only eight annas per head per annum. Hence it compares very favourably with the eradication campaign. If it lacks the thrill of eradication it serves the collateral effects of controlling fly-borne diarrhœa and dysentery and flea-borne plague. And who knows if a domestic service of D.D.T. spray may not eventually be adopted by the householder almost like painting the wood or limewashing the wall ? Or perhaps he would agree to pay to the State a small *per capita* sum per year in return for the service which may thus be made self-supporting. The modern trend for eradication of a species is just taking shape. But apart from the economics of the case one should, as stressed by Soper (*loc. cit.*), keep a sane balance, all factors bearing on each individual case being examined. Thus not only should the feasibility of eradication of a species be thoroughly explored compared with the annual recurrent cost of species sanitation (without eradication) but if the need for house spraying for control of other insects is established and if in that process malaria can also be controlled the question of eradication of the vector anopheline at considerable capital cost may be wholly unnecessary. This is however not to deny the utility of eradication campaigns under restricted specialized conditions. Perhaps an evolution of the modern times is to relegate malaria control by D.D.T. indoor residual spray to the general public health worker and for the malariologist to embark upon eradication campaigns by way of breaking new ground especially when his services are 'threatened' to be no longer required in his old occupation !

In our experience no State service has ever received such a degree of co-operation as in the day-to-day conduct of the D.D.T. scheme. Most of the difficulties expressed in the previous report have been overcome. Criticisms are still voiced and made to high officials but considering that, psychologically, appreciation is hardly ever expressed so vocally as criticism and considering the magnitude of the scheme critics have been few and enthusiasts very many indeed. Practically the only clamour at present is to extend the scheme even to the smallest village, malarious or not. There has been no record of even a single instance of bad effects due to D.D.T. Indeed when a complaint from a city doctor to the Government about the reported prevalence of conjunctivitis possibly due to D.D.T. spraying was being enquired into, the local people both official and non-official entirely missed the good intentions of the critic, stoutly denied the prevalence of any conjunctivitis at all, though in fact there were a few cases but entirely due to different causes than irritation by D.D.T. and protested against what they called mischievous interference with a large-scale scheme of proved beneficent value by throwing unwarranted hints about its evil effects. The critic had no such intention whatever but merely called the attention of the authorities to what came within his knowledge and stressed the need for an enquiry. This was duly made and D.D.T. has been shown to be entirely blameless. Indeed if it had any such irritating effect it should make itself felt on the hundred and fifty members of the staff who have handled it day in and day out for more than 2 years

now. There has been no ill effect on them whatever. Besides, insecticides may, if at all, help in reducing epidemic conjunctivitis so common when the mango is in bloom by destroying insects which transmit infection mechanically from eye to eye.

The Government of Bombay has sanctioned the institution of a similar scheme for every village in Thana District comprising a population of 618,000 with effect from the current year and work has been started early in September. Similar proposals are also likely to be sanctioned for three more districts, viz. Ahmedabad, Kaira and Bijapur, with effect from the next year. Surveys are in progress in Sholapur, Poona, Nasik, West and East Khandesh and Panchmahals and on their completion proposals for control will be submitted.

SUMMARY.

The results of operation of a large-scale rural malaria control project in Dharwar and Kanara districts in Bombay Province, India, are presented for the second year of its operation.

Except for a slight increase in the area and population benefited and the slight consequent increase in cost the details of the scheme as regards spraying technique, dosage and frequency of application and structures sprayed have remained the same as previously described. The *per capita* cost has gone up to Re. 0-8-0 per head due to increased wages and higher price of D.D.T.

The reduction in *fluviatilis* is of the order of 99 per cent in the second year and in *culicifacies* 90 per cent as compared with 90 per cent and 70 to 80 per cent in the first year.

Cumulative spleen rates have shown a further reduction in Dharwar District from 19·6 per cent to 10·6 per cent and in Kanara District from 14·4 per cent to 11·6 per cent in the sprayed villages. Infant parasite rates have almost reached zero level in both districts. Childhood parasite rates are only 0·9 per cent in Dharwar and 2·7 per cent in Kanara as compared with 4·3 per cent and 3·8 per cent respectively in the previous year. In the unsprayed villages they were 5·2 per cent in Dharwar and 19·5 per cent in Kanara as compared with 7·5 per cent and 14·6 per cent respectively during the last year.

There has been in the scheme area, a saving in 1947, of at least 300,000 cases of malaria, of 600 deaths due to malaria and about 600 deaths due to diarrhœa and dysentery. Never have benefits previously been demonstrated in Public Health in the Tropics in such a spectacular manner and within such a short period. It bespeaks the changed attitude of the country that a Nation's health is a Nation's asset.

REFERENCES.

Aziz, M. (1948) ...	... Proceedings of the Fourth International Congress on Malaria. Washington. 1948.
Soper, Fred. L. (1948) ...	*Ibid.*
Viswanathan, D. K., and Ramachandra Rao, T. (1947).	*Ind. J. Mal.*, **1**, 4, pp. 503-542.

TABLE I.

Population and number of villages included in the D.D.T. scheme. Dharwar, Kanara and Belgaum districts, during 1947-48.

Taluka.	Total population.	Total number of inhabited villages.	Actually included in the scheme.				Season of spraying.
			Population.	Per cent.	Villages.	Per cent.	
Kanara District.							
Sirsi Rice tract	43,274	238	9,853	86·4	38	50·8	Rice tract in July–Nov.; Garden tract in Dec.–June.*
Sirsi Garden tract			27,568		83		
Siddapur ...	34,126	195	31,527	92·3	128	65·6	Dec.–June.*
Yellapur ...	15,227	123	12,026	78·9	53	43·08	Oct.–June.
Haliyal ...	28,204	92	23,257	82·4	51	55·4	July–Nov.
Mundgod ...	10,894	61	9,130	83·8	29	47·5	Do.
Supa	14,812	126	11,535	77·8	33	26·2	Oct.–June.
Karwar ...	68,376	61	47,731	69·7	38	62·3	Dec.–June*.
Ankola ...	42,213	80	14,383	34·1	24	30·0	
Kumta ...	71,745	126	37,812	52·7	28	32·2	
Honavar ...	66,980	91	43,694	65·2	54	59·3	
Bhatkal ...	45,306	57	34,714	76·6	21	36·8	
TOTAL ...	441,157	1,250	303,230	68·7	567	45·3	

* In all December–June areas, selected villages receive advance spraying in October and November.

TABLE I—*contd.*

Taluka.	Total population.	Total number of inhabited villages.	ACTUALLY INCLUDED IN THE SCHEME.				Season of spraying.
			Population.	Per cent.	Villages.	Per cent.	
Dharwar District.							
Dharwar ...	130,070	124	78,324	60·2	36	29·0	Dharwar Town included.
Kalghatgi ...	41,986	85	33,512	79·8	47	55·3	
Hubli	169,616	73	27,648	16·3	23	31·5	
Bankapur ...	81,442	138	34,778	42·7	25	18·1	
Haveri ...	112,973	127	58,903	52·1	40	31·5	
Ranebennur ...	121,422	120	82,493	67·9	52	43·3	
Hangal ...	70,796	144	48,302	68·2	64	44·4	
Kod	104,929	168	48,808	46·5	47	28·0	
Gadag ...	127,375	59	29,281	23·0	20	33·9	
Ron	105,930	84	11,776	11·1	15	17·8	
Mundargi ...	36,759	42	23,664	63·0	15	35·7	
Navalgund ...	68,235	56	*nil*	...	*nil*	...	
Nargund ...	29,483	31	*nil*	...	*nil*	...	
TOTAL ...	1,201,016	1,251	476,989	39·7	384	30·7	

Belgaum District.							
Belgaum ...	158,229	115	11,092	7·0	18	15·6	July–Nov.
Khanapur ...	79,940	215	31,601	39·5	48	22·3	July–Nov.
TOTAL ...	238,169	330	42,693	19·6	66	20·0	
Total for existing scheme.	...	...	822,912	...	1,017	...	

* In all December–June areas, selected villages receive advance spraying in October and November.

TABLE II.

Density of anopheline adults, Kanara District.

Month.	SPRAYED VILLAGES.						UNSPRAYED VILLAGES.					
	HUMAN DWELLINGS.			CATTLESHEDS.			HUMAN DWELLINGS.			CATTLESHEDS.		
	Time spent, hours.	Per 10 man-hours.		Time spent, hours.	Per 10 man-hours.		Time spent, hours.	Per 10 man-hours.		Time spent, hours.	Per 10 man-hours.	
		fluviatilis.	All Anopheles.		*fluviatilis.*	All Anopheles.		*fluviatilis.*	All Anopheles.		*fluviatilis.*	All Anopheles.
1947.												
Jul.	109·5	0·1	4·2	27·0	0·0	361·5	106·0	0·0	28·5	28·5	0·0	268·1
Aug.	159·8	0·1	18·6	49·2	1·0	183·5	108·7	3·9	74·8	24·3	3·3	300·8
Sep.	60·0	0·0	4·8	16·5	0·6	180·0	126·0	2·2	34·5	34·5	0·6	245·6
Oct.	112·0	0·0	4·2	33·0	0·0	189·1	83·0	3·5	32·3	24·0	0·8	165·8
Nov.	81·0	0·0	0·3	32·5	0·0	175·7	82·0	3·2	36·8	38·0	1·1	151·6
Dec.	119·0	0·0	1·1	48·0	0·4	160·1	262·5	1·5	38·4	125·0	0·5	107·8
1948.												
Jan.	34·8	0·0	0·9	142·5	0·1	117·5	279·0	1·3	26·5	111·0	1·3	138·6
Feb.	308·0	0·0	1·6	119·5	0·0	128·0	193·0	1·9	19·4	85·0	1·2	108·7
Mar.	334·5	0·0	1·6	148·0	0·3	80·4	215·5	1·4	26·3	94·5	1·1	91·8
Apr.	300·5	0·0	1·6	132·5	0·2	81·8	209·5	1·7	21·6	94·5	1·6	102·0
May	242·5	0·04	1·3	109·0	0·2	76·9	172·5	1·2	21·0	80·5	0·8	89·2
Jun.	173·0	0·0	0·6	73·0	0·0	100·2	145·5	1·0	24·8	65·5	0·2	111·6

TABLE III.

Density of anopheline adults, Dharwar District.

Month.	SPRAYED VILLAGES.						UNSPRAYED VILLAGES.					
	HUMAN AND MIXED DWELLINGS.			CATTLESHEDS.			HUMAN AND MIXED DWELLINGS.			CATTLESHEDS.		
	Time spent, hours.	Per 10 man-hours.		Time spent, hours.	Per 10 man-hours.		Time spent, hours.	Per 10 man-hours.		Time spent, hours.	Per 10 man-hours.	
		A. culicifacies.	All Anopheles.		*A. culicifacies.*	All Anopheles.		*A. culicifacies.*	All Anopheles.		*A. culicifacies.*	All Anopheles.
1947.												
Jul.	93·5	0·2	29·4	73·0	5·2	59·2	133·7	68·5	121·1	28·3	20·4	130·0
Aug.	200·2	6·0	31·6	53·2	20·8	196·8	212·5	36·2	107·5	67·0	38·5	177·8
Sep.	173·2	0·5	31·9	51·8	9·2	156·3	193·0	70·4	170·6	46·3	110·0	426·3
Oct.	227·8	3·4	23·1	77·5	14·6	156·5	197·6	85·3	229·5	61·8	99·8	349·3
Nov.	232·3	1·6	11·7	63·2	6·0	56·8	175·3	90·3	164·6	53·3	136·9	296·6
Dec.	235·7	0·7	9·6	59·0	1·4	51·5	151·2	48·3	98·7	44·5	63·6	184·5
1948.												
Jan.	82·8	0·7	4·9	14·0	1·4	43·6	82·7	47·9	81·5	105·7	68·3	163·9
Feb.	86·3	0·0	3·9	19·3	0·0	32·7	119·4	25·7	63·1	24·6	71·2	190·0
Mar.	96·0	0·1	14·9	24·0	0·8	67·0	122·5	19·5	58·0	31·3	28·8	171·2
Apr.	81·5	0·0	10·8	20·0	0·0	63·0	67·2	20·5	51·7	16·8	91·5	220·5
May	98·7	0·0	4·3	24·5	0·0	45·3	95·3	8·4	19·0	25·0	27·6	64·4
Jun.	128·3	0·4	9·3	35·5	1·7	32·4	147·0	9·9	31·1	40·5	16·1	75·3

TABLE IV.

Kanara District spleen and parasite rates in unsprayed villages, 1947-48.

Taluka and village.	Spleen rate, 1946-47 per cent.	SPLEEN RATE IN 1947-48.			PARASITE RATE IN 1947-48.					
		Number examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number examined.	Number showing malaria parasites.	Parasite rate, per cent.	Parasite species. V.	F.	M.
1	2	3	4	5	6	7	8	9		
Sirsi.										
Yasle	...	8	6	...	...	...	...		...	
Landakanhalli ...	...	9	6	...	9	1	...	1	0	0
Heggar	...	11	8	72·7	...	...	...		...	
Umblikop	100·0	13	11	84·6	7	1	...	1	0	0
Uplekop	91·6	10	9	90·0	10	2	20·0	0	2	0
Gowdalli	100·0	9	8	...	9	3	...	1	2	0
Narebail	...	12	10	83·3	12	3	25·0	1	2	0
TOTAL ...	...	72	58	80·5	47	10	21·2	4	6	0

Siddapur.										
Malanhali	...	14	5	35·7	13	2	15·4	1	1	0
Chandraghatgi ...	...	8	4	...	8	1	...	0	1	0
Kalanhali	...	3	2	...	3	1	...	0	1	0
Hangerkhand ...	...	12	4	33·3	12	2	16·6	1	1	0
Hoskop	...	9	4	...	9	1	...	0	1	0
Padwanbail ...	...	3	1	...	3	1	...	0	1	0
Matigar	...	4	1	...	4	1	...	1	0	0
Dudgimane ...	...	1	0	...	1	0	...		...	
Nagarbail	...	4	1	...	4	0	...		...	
Hiremag	...	6	2	...	6	1	...	0	1	0
Mankod	...	10	1	10·0	10	1	10·0	0	1	0
Haltot	...	3	2	...	3	0	...		...	
TOTAL ...	...	77	27	35·1	76	11	14·5	3	8	0

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE IV—*contd.*

Taluka and village.	Spleen rate, 1946-47, per cent.	Spleen rate in 1947-48.			Parasite rate in 1947-48.			
		Number examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number examined.	Number showing malaria parasites.	Parasite rate, per cent.	Parasite species. V. F. M.
1	2	3	4	5	6	7	8	9
Ankola.								
Averse	...	106	38	35·8	...	...	...	...
Mundgod.								
Nyasargi	80·9	12	9	75·0	12	0	0·0	...
Kalgankop ...	...	14	14	100·0	12	0	0·0	...
Kyasankeri ...	...	9	8	...	9	2	...	0 2 0
Malwalli	85·7	16	13	81·2	17	1	8·9	0 1 0
Ajjihalli	76·5	6	5	...	7	0	0·0	...
TOTAL ...	...	57	49	85·9	57	3	5·3	0 3 0

Haliyal.										
Mundwad	...	40	12	30·0	18	2	11·1	1	1	0
Kurigaddi	...	16	11	68·8	...	...	...		...	
TOTAL ...	...	56	23	41·1	18	2	11·1	1	1	0
Supa.										
Badasgaddi ...	...	14	9	64·3	11	4	36·4	3	1	0
Kariwadi	...	13	10	76·9	13	10	76·9	8	2	0
Vainy	...	13	7	53·9	...	...	...		...	
TOTAL ...	...	40	26	65·0	24	14	58·3	11	3	0
Karwar.										
Gopshitta	...	29	11	37·9	...	...	...		...	
Sadashivgad ...	...	41	6	14·6	...	...	...		...	
TOTAL ...	...	70	17	24·3	...	...	...		...	

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE IV—*concld.*

Taluka and village.	Spleen rate, 1946-47, per cent.	Spleen rate in 1947-48.			Parasite rate in 1947-48.					
		Number examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number examined.	Number showing malaria parasites.	Parasite rate, per cent.	Parasite species. V.	F.	M.
1	2	3	4	5	6	7	8	9		
Honavar.										
Malkod	...	20	4	20·0	19	4	...	1	3	0
Kot	...	9	6	...	9	3	...	0	3	0
Tumbebail ...	...	7	6	...	7	3	...	1	2	0
Balewatti	...	7	3	...	7	1	...	0	1	0
Sampolli	...	6	4	...	6	2	...	1	1	0
Manki	...	33	18	54·5	35	6	...	2	3	0
Heggargadde ...	...	2	2	...	2	0	...		...	
Keroli	...	45	9	20·0	24	4	...	1	3	0
TOTAL ...	...	129	52	40·3	109	23	21·1	6	16	1

Bhatkal.											
Aravakki ...	...	...	8	8	...	8	2	...	1	1	0
Kulavadi ...	...	...	5	5	...	5	2	...	0	2	0
Kekkod ...	...	...	2	2	...	2	2	...	0	2	0
Hallari ...	...	...	2	2	...	2	1	...	0	1	0
Beshi ...	...	...	8	6	...	8	3	...	0	3	0
Hejli ...	...	...	3	2	...	2	0	...		...	
Herur ...	...	...	8	5	...	8	2	...	0	2	0
Hedvalli ...	...	...	12	9	75·0	12	4	33·3	1	3	0
Belki ...	...	...	31	13	41·9	32	6	18·8	0	6	0
Venkatapur	...	...	49	4	6·2	47	5	10·6	0	4	0
Bilalkhand	...	...	12	6	41·6	12	2	16·6	0	2	0
TOTAL	...	...	140	62	44·3	138	29	21·0	3	26	0
GRAND TOTAL	...	...	747	352	47·1	469	92	19·6	28	63	1

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE V.

Kanara District spleen and parasite rates in sprayed villages, 1947-48.

Taluka and village.	Spleen rate, 1946-47, per cent.	Spleen rate in 1947-48.			Parasite rate in 1947-48.					
		Number examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number examined.	Number showing parasites.	Parasite rate, per cent.	Parasite species.		
								V.	F.	M.
1	2	3	4	5	6	7	8	9		
Sirsi.										
Sirsi Town ...	4·6	373	15	4·0	205	2	1·0	1	1	0
TOTAL ...	4·6	373	15	4·0	205	2	1·0	1	1	0
Siddapur.										
Siddapur Town ...	38·0	100	2	2·0	100	3	3·0	1	1	1
Kangod	...	80	7	8·7	80	3	3·8	1	2	0
Nidgod	...	20	2	10·0	20	1	5·0	0	1	0
Bilgi	15·5	60	4	6·6	60	2	3·3	1	1	0
Harshikatti ...	45·0	25	2	8·0	25	1	4·0	0	1	0
Tyagli	24·2	30	2	6·6	30	1	3·3	0	1	0
Kansur	13·3	26	3	11·5	26	1	3·8	0	1	0

Manmane	...	41	3	7·3	41	1	2·4	0	1	0
Hulgeri	13·3	31	3	9·6	31	1	3·2	1	0	0
Mavingundi and Jog Falls.	16·0	21	4	19·0	21	1	4·8	1	0	0
Total ...	...	434	32	7·3	834	15	3·5	5	9	1
Yellapur.										
Yellapur Town ...	18·8	495	46	9·3	50	0	0·0		...	
Kirwatti	15·4	51	8	15·6	30	1	3·3	0	1	0
Nandolli	...	15	8	53·3	...	...	...		...	
Total ...	...	561	62	11·0	80	1	1·2	0	1	0
Mundgod.										
Mundgod Town ...	17·9	100	11	11·0	61	0	0·0		...	
Pala	10·9	80	5	6·2	50	1	2·0	0	1	0
Chigalli	21·8	75	9	12·0	52	0	0·0		...	
Total ...	...	255	25	9·8	163	1	2·6	0	1	0

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE V—*contd.*

Taluka and village.	Spleen rate, 1946-47, per cent.	Spleen rate in 1947-48.			Parasite rate in 1947-48.					
		Number examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number examined.	Number showing parasites.	Parasite rate, per cent.	Parasite species. V.	F.	M.
1	2	3	4	5	6	7	8	9		
Haliyal.										
Haliyal Town ...	6·8	495	46	9·3	...	...	...	...		
Nagshitti	...	23	4	17·4	20	1	5·0	1	0	0
Kanehanhalli Khurd ...	24·0	28	4	14·3	...	...	...	...		
Mundwalli	...	38	5	13·2	14	0	0	...		
Dasgi	...	33	5	15·2	20	0	0	...		
Tergaon	5·0	120	3	2·5	80	0	0	...		
Havgi	...	57	2	3·5	30	0	0	...		
Kerwad	...	27	1	3·7	27	0	0	...		
Kanchinhalli Budruk ...	...	61	8	13·1	...	...	...	...		
TOTAL ...	...	882	78	8·7	191	1	5·0	1	0	0
Supa.										
Nandigadde ...	...	7	4	...	6	1	16·7	1	0	0
Jagalbet	...	43	6	14·0	19	1	5·3	1	0	0

Supa	...	37	7	18·9	19	3	15·8	2	1	0
Joida	...	17	6	35·3	...	...	...		...	
Kalassai	...	7	1	...	...	...	...		...	
TOTAL ...	...	111	24	21·6	44	5	11·4	4	1	0
Karwar.										
Malgi	51·7	47	11	23·4	...	...	...		...	
Sawantwada ...	78·9	13	4	30·7	13	0	...		...	
Madhewada ...	67·5	31	6	19·3	27	1	3·7	0	1	0
Kolge	62·9	13	4	30·7	13	0	...		...	
Devalmakki ...	...	32	13	40·1	...	...	...		...	
Bergal	18·2	26	4	15·3	...	...	...		...	
Kerwadi	...	76	9	11·7	...	...	...		...	
Katar	...	31	8	25·8	...	...	...		...	
Mudgeri	48·0	41	8	19·5	35	5	14·2	5	0	0
Honkan	44·4	36	9	25·0	30	2	6·6	1	1	0
Kadra	36·3	16	4	25·0	...	...	...		...	
TOTAL	...	362	80	22·0	118	8	6·8	6	2	0

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE V—*contd.*

Taluka and village.	Spleen rate, 1946-47, per cent.	Spleen rate in 1947-48.			Parasite rate in 1947-48.					
		Number examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number examined.	Number showing parasites.	Parasite rate, per cent.	Parasite species.		
								V.	F.	M.
1	2	3	4	5	6	7	8	9		
Ankola.										
Agsur	69·2	24	2	8·3	...	...	...	...		
Adlur	66·6	15	2	13·3	...	...	...	...		
Belse	16·0	24	2	8·3	...	...	...	...		
Shirur	32·0	22	3	13·6	...	...	...	...		
Mogta	37·9	30	3	10·0	...	...	...	...		
Morhalli	57·1	3	0	...	...	...	...	...		
Ūlware	...	83	3	9·1	...	...	...	...		
Gurdbala	59·0	31	1	3·2	...	...	...	...		
TOTAL ...	...	182	16	8·7	...	...	...	...		
Honavar.										
Gundbal	...	47	6	12·8	47	3	...	1	2	0
Gersoppa	75·0	63	6	9·5	60	3	...	0	3	0
Honavar	...	93	3	3·2	91	1	...	0	1	0
Chendavar ...	62·8	65	4	6·1	59	3	...	0	3	0

Kadle	11·1	40	4	10·0	40	1	...	0	1	0
Asolli Mundgod ...	31·4	28	2	7·1	28	1	...	0	1	0
Balkur	35·5	55	3	5·4	53	1	...	0	1	0
Hosad	10·0	87	7	8·0	87	1	...	0	1	0
Kekkar	...	96	13	13·5	...	...	...		...	
Kadtoka	...	105	18	17·1	...	...	...		...	
Madgeri	...	38	5	13·2	...	...	...		...	
Navilgone	...	79	10	12·7	...	...	...		...	
TOTAL ...	...	733	81	11·0	465	14	3·0	1	13	0
Kumta.										
Kalve	...	25	13	52·0	20	3	...	1	2	0
Santiguli	...	25	12	48·0	20	2	...	2	0	0
Kujalli	...	50	6	12·0	40	0	...		...	
Harodi	...	25	1	4·0	20	0	...		...	
Karkimakki ...	...	50	2	4·0	20	0	...		...	
Mirjan	...	50	4	8·0	50	0	...		...	
Bargi	...	50	5	10·0	28	0	...		...	
Madangeri	...	50	4	8·0	25	0	...		...	
Divgi	...	50	1	2·0	50	0	...		...	
TOTAL ...	...	375	48	12·8	273	5	1·8	3	2	0

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE V—*concld.*

Taluka and village.	Spleen rate, 1946-47, per cent.	Spleen rate in 1947-48. Number examined.	Number with enlarged spleen.	Spleen rate, per cent.	Parasite rate in 1947-48. Number examined.	Number showing parasites.	Parasite rate, per cent.	Parasite species. V.	F.	M.
1	2	3	4	5	6	7	8	9		
Bhatkal.										
Bhatkal	4·4	228	14	6·1	185	3	1·6	0	3	0
Marukeri	59·5	48	14	29·7	...	...	...		...	
Kaikeri	...	54	20	87·0	...	...	...		...	
Muttoli	...	37	5	13·5	36	2	5·6	0	2	0
Kuntawani ...	61·1	27	9	33·3	27	2	7·4	0	2	0
Kotkhand	52·9	28	2	7·1	27	2	7·4	0	2	0
Kitre	52·9	24	3	12·5	26	1	3·8	0	1	0
Shirali	...	50	2	4·0	50	0	...		...	
Mavalli	...	23	6	26·1	23	3	13·0	0	2	1
TOTAL ...	...	519	95	18·3	374	13	3·5	0	12	1
GRAND TOTAL ...	...	4,787	556	11·6	2,347	65	2·7	21	42	2

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE VI.

Dharwar District spleen and parasite rates in unsprayed villages, 1947-48.

Taluka and village.	Spleen rate, 1946-47, per cent.	SPLEEN RATE IN 1947-48.			PARASITE RATE IN 1947-48.					
		Number of children examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number of children examined.	Number showing malaria parasites.	Parasite rate, per cent.	Parasite species. V.	F.	M.
1	2	3	4	5	6	7	8	9		
Dharwar.										
Guladkop	...	63	33	52·4	48	5	10·4	2	3	0
Maradgi	...	51	8	15·7	42	1	2·4	0	1	0
Somapur	...	54	9	16·6	24	0	...		...	
Inamati Hebli ...	...	101	4	4·0	32	0	...		...	
Aravatgi	...	19	6	84·2	19	2	0·5	1	1	0
Amboli	...	18	14	77·7	18	2	11·1	0	2	0
Jogyellapur ...	...	32	7	21·9	...	...	...		...	
Tadkod	...	106	17	16·0	51	2	3·9	1	1	0
Kalkeri	...	52	16	30·8	49	3	6·3	1	2	0
Khanapur	...	54	9	16·6	...	...	...		...	
Singanhalli ...	...	46	24	52·2	38	1	2·7	1	0	0
TOTAL ...	...	596	147	24·6	321	16	5·0	6	10	0

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE VI—*contd.*

Taluka and village.	Spleen rate, 1946-47, per cent.	SPLEEN RATE IN 1947-48.			PARASITE RATE IN 1947-48.					
		Number of children examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number of children examined.	Number showing malaria parasites.	Parasite rate, per cent.	Parasite species. V.	F.	M.
1	2	3	4	5	6	7	8	9		
Kalghatgi.										
Hulkinkatti ...	...	52	26	50·0	48	0	0·0	...		
Tambur	...	36	28	77·7	19	1	5·2	0	1	0
Tavargeri	...	32	21	65·6	21	1	4·2	1	0	0
Bisanhalli	...	21	10	47·6	13	1	7·6	0	1	0
TOTAL ...	...	141	85	60·3	101	3	3·0	1	2	0
Bankapur.										
Bisnalli	...	25	20	80·0	18	5	27·7	2	3	0
Silvansomapur ...	...	42	4	9·5	...	...	...	...		
Kinimilhalli ...	...	50	7	14·0	28	0	*nil*	...		
Tevanamavlihalli ...	...	80	11	13·7	...	...	...	...		

Andalgi ...	...	...	52	12	23·0	...	...	...		...	
Kurubaimallur	...	...	48	4	8·3	...	...	...		...	
Hulgur ...	...	...	100	11	11·0	...	...	...		...	
Hurlikuppi	...	...	64	12	12·7	...	...	...		...	
Ingulgi ...	...	...	121	21	17·3	...	...	...		...	
Chicbendigeri	...	...	30	11	36·6	...	...	...		...	
TOTAL	...	...	612	113	18·5	46	5	10·2	2	3	0
Hangal.											
Sirmapur ...	...	...	24	9	37·5	...	...	...		...	
Gejjanhalli	...	...	23	7	30·4	...	...	...		...	
Markop ...	...	...	30	16	33·3	14	1	7·1	1	0	0
Kelwarkop	...	...	58	8	13·7	18	1	5·5	1	0	0
Maharajpet	...	...	25	13	52·0	11	1	9·1	1	0	0
TOTAL	...	...	160	53	33·1	43	3	7·0	3	0	0

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE VI—*contd.*

Taluka and village.	Spleen rate, 1946-47, per cent.	Spleen rate in 1947-48. Number of children examined.	Spleen rate in 1947-48. Number with enlarged spleen.	Spleen rate in 1947-48. Spleen rate, per cent.	Parasite rate in 1947-48. Number of children examined.	Parasite rate in 1947-48. Number showing malaria parasites.	Parasite rate in 1947-48. Parasite rate, per cent.	Parasite rate in 1947-48. Parasite species. V. F. M.
1	2	3	4	5	6	7	8	9
Haveri.								
Surangi	...	87	49	56·3	...	...	...	...
Bommankatti ...	...	64	6	9·3	24	...	...	...
Yattinhalli ...	...	38	3	7·8	...	...	...	...
Yellapur	...	23	1	4·3	14	...	...	...
Lingapur	...	60	5	8·3	42	...	...	...
Hankapur	...	56	6	10·7	32	1	3·1	0 1 0
Malapur	...	38	3	7·8	...	...	...	...
Basapur	...	36	1	2·7	12	...	...	...
Agadi	...	100	13	13·0	...	...	...	...
Korwalli	...	84	15	17·8	...	...	...	...

Kubbur ...	...	...	90	24	26·6	...	...	...	...
Hommardi	...	...	39	8	20·5	...	...	...	...
Chicklingadhalli	...	...	50	6	12·0	...	...	...	...
Kurbagonda	...	...	50	14	28·0	...	...	...	...
Hanumanhalli	...	...	38	10	26·3	...	...	...	...
Kurdkodihalli	...	...	50	7	14·0	...	...	...	...
TOTAL	...	...	903	171	18·9	124	1	0·8	0 1 0
Ranebennur.									
Yemmihosalli	...	...	40	1	2·5	30	...	...	...
Horogoppa	...	...	63	14	22·2	26	1	3·8	0 1 0
Damdgihalli	...	...	38	6	15·0	15	0	...	...
Kollapur ...	...	...	42	7	16·6	...	...	...	...
Aladgeri ...	...	...	80	12	15·0	...	...	...	...
TOTAL	...	...	263	40	15·2	71	1	1·4	0 1 0

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE VI—*contd.*

Taluka and village.	Spleen rate, 1946-47, per cent.	SPLEEN RATE IN 1947-48.			PARASITE RATE IN 1947-48.			
		Number of children examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number of children examined.	Number showing malaria parasites.	Parasite rate, per cent.	Parasite species. V. F. M.
1	2	3	4	5	6	7	8	9
Kod Taluka.								
Dodgubbi	...	51	11	2·1	...	...	...	...
Sangubbi	...	51	8	21·5	...	...	...	...
Hiremorab ...	...	20	2	10·0	...	...	...	...
Kandibagal ...	...	31	5	16·1	...	...	...	...
Yattinhalli ...	...	81	65	80·2	36	7	19·4	3 4 0
Songakop	...	24	18	75·0	...	...	...	...
Yellapur	...	31	4	12·9	...	...	...	...
Nagvad	...	180	71	39·4	...	...	...	...
Yelinhalli	...	40	18	45·0	...	...	...	...
Gangaikop ...	...	11	6	55·0	...	...	...	...
Kanvisodgeri ...	...	60	15	25·0	...	...	...	...
Dhupadhalli ...	...	36	6	16·6	...	...	...	...
Ingalgondi ...	...	100	13	13·0	...	...	...	...
Madrinhalli ...	...	64	29	45·3	...	...	...	...

Chickbudihal ...	...	56	7	12·5	...	...	...		...	
Karwadi	...	112	16	14·3	...	...	...		...	
Chinnikatti ...	...	83	8	10·8	...	...	...		...	
Kachvi	...	104	26	25·0	...	...	...		...	
Nulgeri	...	64	9	14·0	...	...	...		...	
TOTAL ...	...	1,199	338	28·1	36	7	19·4	3	4	0
Hubli.										
Nagshittikop ...	...	36	1	2·5	31	1	3·2	1	0	0
Bengari	...	32	0	0·0	20	0	0·0		...	
Birnal	...	36	1	2·7	26	0	0·0		...	
Anchatgeri ...	...	41	31	75·6	24	4	16·6	2	2	0
Gargyal	...	28	22	78·5	21	4	19·4	1	3	0
Budursinghi ...	...	17	4	23·5	17	1	5·8	0	1	0
Mannur	...	40	7	17·5	21	1	4·7	1	0	0
TOTAL ...	...	230	66	28·6	160	11	6·9	5	6	0
Gadag.										
Hulkoti	...	61	15	24·6	...	...	...		...	
Binkankatti ...	...	54	11	20·4	...	...	...		...	
Hirehandinhal ...	...	52	13	25·0	...	...	...		...	
TOTAL ...	...	157	39	25·5	...	...	...		...	

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE VI—*concld.*

Taluka and village.	Spleen rate, 1946-47, per cent.	Spleen rate in 1947-48.			Parasite rate in 1947-48.			
		Number of children examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number of children examined.	Number showing malaria parasites.	Parasite rate, per cent.	Parasite species. V. F. M.
1	2	3	4	5	6	7	8	9
Mundargi.								
Bennihalla ...	...	38	8	21·0	...	...	...	...
Kadampur ...	...	65	38	58·5	...	...	...	...
TOTAL ...	...	103	46	44·6	...	...	...	...
GRAND TOTAL ...	...	4,374	1,098	25·1	902	47	5·2	20 27 0

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE VII.

Dharwar District spleen and parasite rates in sprayed villages, 1947-48.

Taluka and village.	Spleen rate, 1946-47, per cent.	SPLEEN RATE IN 1947-48.			*PARASITE RATE IN 1947-48.					
		Number of children examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number of children examined.	Number showing malaria parasite.	Parasite rate, per cent.	Parasite species. V.	F.	M.
1	2	3	4	5	6	7	8	9		
Dharwar.										
Dharwar Town.										
Hosayellapur ...	16·0	93	3	3·2	...	...	...		...	
Line Bazaar ...	2·4	103	1	1·0	...	...	...		...	
Gandhi Chowk ...	1·2	97	1	1·0	...	...	...		...	
TOTAL DHARWAR TOWN ...	...	293	5	1·7	...	...	...		...	
Alnavar	30·8	120	10	8·3	40	1	2·5	0	1	0
Gadag	...	84	2	2·4	84	...	...		...	
Mummigatti ...	14·3	61	3	4·9	32	0	0·0		...	
Mugad	32·9	64	6	9·4	23	...	...		...	
Kumbarkop ...	...	51	30	58·8	24	2	8·3	1	1	0
Kogilkeri	...	64	36	56·3	29	1	8·4	1	0	0
Kadabgatti ...	...	42	11	26·1	26	1	2·8	0	1	0
Mandihal	...	48	5	10·4	...	...	...		...	
Navalur	27·4	102	10	9·8	52	0	0·0		...	
Rayapur	...	68	5	7·4	51	0	0·0		...	
Sattur	...	42	3	7·1	38	0	0·0		...	
Kelgeri	37·6	97	20	20·6	42	1	2·4	1	0	0
Narendra	14·5	92	7	7·6	32	0	0·0		...	
Tegur	44·8	94	20	21·3	38	0	0·0		...	
Tadshinkop ...	...	32	3	9·4	21	0	0·0		...	
TOTAL ...	...	1,354	176	13·0	542	6	1·1	3	3	0

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE VII—*contd.*

Taluka and village.	Spleen rate, 1946-47, per cent.	Spleen rate in 1947-48. Number of children examined.	Number with enlarged spleen.	Spleen rate, per cent.	Parasite rate in 1947-48. Number of children examined.	Number showing malaria parasite.	Parasite rate, per cent.	Parasite species. V.	F.	M.
1	2	3	4	5	6	7	8		9	
Kalghatgi.										
Dummad	...	38	2	5·2	21	0	0·0		...	
Dasanur	...	35	3	8·5	24	0	0·0		...	
Jamchal	...	32	4	12·5	15	0	0·0		...	
Hirehongal ...	...	63	5	7·9	32	0	0·0		...	
Kalghatgi	8·7	134	9	6·9	56	1	1·7	0	1	0
Dastikop	13·5	52	6	4·5	32	1	3·2	1	0	0
Devikop	...	86	10	4·6	32	1	3·2	0	1	0
Machapur	19·0	24	2	8·3	12	0	0·0		...	
Beliantra	...	31	3	9·6	13	0	0·0			
Bammigatti ...	...	40	3	7·5	...	...	...		...	
Madkihonnalli ...	16·6	52	5	9·6	32	0	0·0		...	
Sangdevkop ...	...	31	6	19·3	17	0	0·0		...	
Jinnur	...	44	3	6·8	26	0	0·0		...	
Ramanhal	24·2	61	8	13·1	48	0	0·0		...	
Begur	16·3	52	4	7·6	28	0	0·0		...	
TOTAL ...	...	775	73	9·4	388	3	0·8	1	2	0
Bankapur.										
Tadas	...	45	6	13·3	31	1	3·2	1	0	0
Adursomapur ...	...	66	14	21·2	28	1	3·5	0	1	0
Kamar	...	96	5	5·2	24	0	0·0		...	
Dhundshi	...	78	8	10·2	42	0	0·0		...	
Shiggaon	20·8	148	18	12·1	46	0	0·0		...	
Bankapur	...	123	6	4·0	51	0	0·0		...	
TOTAL ...	...	556	57	10·2	222	2	0·9	1	1	0

Hangal.								
Hangal	...	125	9	7·1	68	0	0·0	...
Balur	...	18	0	0·0	...	...	...	...
Makanwalli ...	...	11	0	0·0	...	...	...	...
Chikkanshi ...	...	31	2	6·4	...	...	...	...
Sheshgiri	...	27	1	3·7	...	...	...	...
Honkan	...	48	2	4·1	...	...	...	...
Tilwalli	...	69	4	5·7	31	0	0·0	...
Bamankatti ...	...	51	4	7·8	...	...	...	...
Alur	...	48	2	4·1	23	0	0·0	...
Balambid	...	80	4	5·0	24	0	0·0	...
Adur	...	42	2	4·7	...	...	...	...
Kodiyellapur ...	...	23	1	4·3	...	...	...	...
Singapur	...	21	1	4·7	...	...	...	...
TOTAL ...	...	594	32	5·4	146	0	0·0	...
Haveri.								
Haveri	8·5	56	2	3·5	34	0	0·0	...
Basavankatti ...	...	32	3	9·3	...	...	...	...
TOTAL ...	...	88	5	5·7	34	0	0·0	...
Ranebennur.								
Motebennur ...	17·0	78	3	3·8	46	0	0·0	...
Chatra	...	40	2	5·0	12	0	0·0	...
Kakol	...	31	2	6·4	14	0	0·0	...
Ranabennur ...	1·2	135	5	3·6	31	0	0·0	...
Karur	10·0	38	1	2·6	27	0	0·0	...
Chalgeri	...	42	1	2·3	21	0	0·0	...
Itgi	22·4	30	0	0·0	12	0	0·0	...
Halgeri	8·0	51	2	3·9	14	0	0·0	...
TOTAL ...	...	445	16	3·6	177	0	0·0	...

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE VII—*concld.*

Taluka and village.	Spleen rate, 1946-47, per cent.	Spleen rate in 1947-48.			Parasite rate in 1947-48.					
		Number of children examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number of children examined.	Number showing malaria parasite.	Parasite rate, per cent.	Parasite species. V.	F.	M.
1	2	3	4	5	6	7	8	9		
Kod.										
Rattihalli	6·0	32	1	3·3	...	...	...		...	
Masur	30·0	82	16	19·5	31	1	3·2	0	1	0
Hirekerur	20·8	58	5	8·6	24	...	...		...	
Chikkerur	16·0	40	3	7·5	...	...	...		...	
TOTAL ...	...	212	25	11·8	55	1	1·8	0	1	0
Hubli.										
Koliwad	...	72	3	4·2	...	...	...		...	
Bhaidwarkop ...	...	40	7	17·5	40	2	5	0	2	0
Amargol	20·2	50	5	10·0	44	1	2·2	1	0	0
Unkal	26·9	35	2	5·7	35	...	...		...	
Keshavapur ...	...	34	1	2·9	...	...	...		...	
Adargunchi ...	4·2	45	2	4·2	45	1	2·2	0	1	0
Kodgunchi ...	...	37	1	2·7	...	...	...		...	
Nulvi	...	41	1	2·4	21	...	...		...	
Gharewadi ...	3·3	30	1	3·3	24	...	...		...	
Raynal	...	28	1	3·5	25	...	...		...	
Ravdihal	...	21	1	4·7	20	...	...		...	
Gokul	12·8	31	1	3·2	21	...	...		...	
TOTAL ...	...	464	26	5·6	275	4	1·5	1	3	0

Gadag.								
Asundi	...	73	8	11·0	...	...	...	...
Malsamudra ...	...	51	8	15·7	...	...	...	...
Chikop	...	32	8	25·0	...	...	...	...
Nagsamudra ...	...	45	12	26·7	...	...	...	...
Hirekop	...	46	10	21·8	...	...	...	...
Advisomapur ...	...	65	9	13·8	...	...	...	...
Papanashi	...	51	7	13·7	...	...	...	...
TOTAL ...	...	363	62	17·1	...	...	...	...
Mundgod.								
Bennihal	...	38	8	21·0	...	...	...	...
Kadampúr ...	...	65	38	58·5	...	...	...	...
Dambal	14·0	76	15	19·8	...	...	...	...
Mundi	...	48	6	12·5	...	...	...	...
Bandur	...	48	6	13·0	...	...	...	...
Mundargi	17·9	103	10	9·7	...	...	...	...
TOTAL ...	...	378	83	21·9	...	...	...	...
GRAND TOTAL ...	...	5,229	555	10·6	1,839	16	0·9	6 10 0

V = *vivax*. F = *falciparum*. M = *malariæ*.

Table VIII.

Belgaum District spleen and parasite survey of Khanapur Taluka, 1947-48.

	Spleen rate, 1946-47, per cent.	Spleen rate in 1947-48.			Parasite rate in 1947-48.					
		Number examined.	Number with enlarged spleen.	Spleen rate, per cent.	Number examined.	Number showing malaria parasite.	Parasite rate, per cent.	Parasite species. V.	F.	M.
Sprayed villages.										
Khanapur	37·5	237	46	19·4	123	3	2·4	0	3	0
Londa	19·0	132	10	7·5	60	0	0·0		...	
Nagargali	100·0	24	16	66·7	9	1	...	1	0	0
Bidi	62·5	63	14	22·2	75	2	2·7	2	0	0
Nandgad J.	39·2	54	14	25·9	11	1	9·1	0	1	0
Nandgad	40·0	143	16	11·2	50	1	2·0	0	1	0
Tawargatti	100·0	27	14	51·8	11	0	0·0		...	
Bamantkop	...	8	7	...	5	2	...	0	2	0
Karambal	21·4	31	5	16·1	...	...	...		...	
Rumewadi	5·5	22	2	9·1	...	...	...		...	
Total ...	...	741	144	19·4	344	10	2·9	3	7	0

Unsprayed villages.

Kupatgeri	...	56	8	14·3	...	...	...	...		
Honkal	...	18	5	27·8	...	...	...	...		
Kaundal	30·8	41	11	26·8	25	2	8·0	1	1	0
Lalwadi	21·4	23	6	26·1	...	...	...	...		
Navge	...	29	7	24·1	...	...	...	...		
Kinkikop	30·0	27	9	33·3	23	3	13·0	0	3	0
Junjivad Golhalli ...	30·8	28	8	28·6	14	1	7·1	0	1	0
Baikwad	...	34	10	29·4	20	2	10·0	1	1	0
Garbanhatti	35·6	30	10	33·3	10	2	20·0	0		0
Kumbharwada ...	94·1	21	19	90·5	21	4	19·0	1	3	0
Sawantwada	91·0	18	16	88·9	12	3	25·0	1	2	0
TOTAL ...	...	325	109	33·5	125	19	13·6	4	13	0

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE IX.

Summary of infant malaria indices in Kanara District in 1947-48.

Sprayed villages.

Taluka.	Village.	Number examined.	Number showing malaria parasites.	Infant parasite rate, per cent.	Species. V.	F.	M.
Sirsi	Sirsi Town ...	100	0	...	...		
Mundgod ...	Mundgod Town ...	25	0	...	...		
Yellapur ...	Yellapur Town ...	30	0	...	...		
Siddapur	Kangod ...	8	0	...	...		
	Nidgod ...	4	0	...	...		
	Manmane ...	3	0	...	...		
	Halgeri ...	7	0	...	...		
	Mavingundi ...	2	0	...	...		
	Kansoor ...	2	0	...	...		
Bhatkal	Marukeri ...	8	0	...	...		
	Kaikini ...	12	1	...	0	1	0
Kumta	Kalve ...	4	0	...	...		
	Kujalli ...	10	0	...	...		
	Harodi ...	8	0	...	...		
	Karkimakki ...	6	0	...	...		
	Mirjan ...	25	0	...	...		
	Bargi ...	10	0	...	...		
	Madangeri ...	8	0	...	...		
	Divgi ...	8	0	...	...		
TOTAL ...	...	280	1	0·4	0	1	0

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE X.

Summary of infant malaria indices in Kanara District in 1947-48.

Unsprayed villages.

Taluka.	Village.	Number examined.	Number showing malaria parasites.	Infant parasite rate, per cent.	Species. V.	F.	M.
Sirsi	(6 villages) ...	18	3	...	2	1	0
Mundgod ...	(4 villages) ...	10	2	...	1	1	0
Siddapur ...	(5 villages) ...	7	1	...	0	1	0
Bhatkal ...	(5 villages) ...	10	3	...	1	2	0
TOTAL ...	(20 villages) ...	45	9	20·0	4	5	0

V = *vivax*. F = *falciparum*. M = *malariæ*.

TABLE XI.

Number of malaria patients treated in public dispensaries in Kanara and Dharwar districts.

Dispensary.	1943.	1944.	1945.	1946.	1947.	REMARKS.
Kanara District.						
Sirsi	5,567	8,763	6,509	4,327	4,254	In these villages some kind of anti-malaria measures have been in operation from 1943-44.
Mundgod ...	4,145	2,934	2,045	1,796	1,962	
Yellapur ...	3,750	3,083	2,742	2,717	2,464	
Haliyal ...	7,603	5,632	4,159	3,782	2,347	
Supa	2,369	1,907	1,772	1,397	1,074	
Dandeli ...	2,871	2,337	1,610	910	1,725	
Manchikeri ...	2,304	1,792	1,819	1,826	1,325	
Kumta ...	9,956	10,279	9,401	4,269	3,364	Spraying operation commenced only in December-January 1946-47.
Ankola ...	3,626	5,175	2,868	1,761	Not available.	
Hokara ...	2,151	4,924	2,176	2,261	2,762	
Siddapur ...	1,190	1,630	2,305	1,786	1,133	
Bhatkal ...	4,746	5,710	6,407	5,263	4,071	
TOTAL ...	50,278	54,166	43,813	32,095	26,491 or 28,252	Assuming Ankola has the same number of cases as in the previous year.
Dharwar District.						
Dharwar ...	4,747	4,719	4,878	2,863	2,930	Spraying commenced in July 1946.
Haveri ...	9,437	7,919	5,267	2,622	2,644	
Hangal ...	4,963	7,321	3,141	1,767	1,423	
Ranebennur ...	7,311	9,611	7,416	3,578	3,512	
Hirakerur ...	2,993	3,392	1,321	1,479	3,457	
Shiggaon ...	4,602	3,603	2,613	1,016	1,120	
Kalghatgi ...	6,009	7,294	5,161	3,405	2,810	
Mundargi ...	783	1,296	1,956	692	602	
TOTAL ...	40,845	45,155	31,753	17,422	18,498	
GRAND TOTAL ...	91,123	99,321	75,566	49,517	44,989	

TABLE XII.

Deaths due to all causes, fevers, malaria, diarrhœa and dysentery in Kanara and Dharwar districts and Bombay Province, 1936–47.

Year.	Kanara.				Dharwar.				Bombay Province.			
	Total deaths from all causes.	Deaths from fever.	Deaths from malaria.	Deaths from dysentery and diarrhœa.	Total deaths from all causes.	Deaths from fever.	Deaths from malaria.	Deaths from dysentery and diarrhœa.	Total deaths from all causes.	Deaths from fever.	Deaths from malaria.	Deaths from dysentery and diarrhœa.
1936 ...	12,960	4,467	1,028	1,105	29,763	8,863	1,946	1,141	497,278	161,150	27,307	30,104
1937 ...	11,716	3,757	867	1,120	26,765	8,722	1,882	912	493,208	164,130	25,373	28,094
1938 ...	12,253	3,791	924	1,347	29,064	10,037	1,586	1,241	547,387	186,363	29,790	34,242
1939 ...	11,653	3,918	876	1,101	27,335	9,373	1,644	1,091	494,887	168,788	28,833	25,567
1940 ...	12,336	4,293	1,041	986	31,809	11,762	2,861	909	501,465	172,858	29,602	22,165
TOTAL ...	60,918	20,226	4,736	5,659	144,736	48,757	9,919	5,294	2,534,225	853,289	140,905	140,172
AVERAGE ...	12,184	4,045	947	1,132	28,947	9,751	1,984	1,059	506,845	170,658	28,181	28,034
1941 ...	11,518	3,635	869	916	38,774	14,272	3,533	1,267	539,737	180,929	32,099	26,351
1942 ...	10,210	3,058	782	779	33,495	10,064	1,977	1,046	516,548	188,356	28,906	26,376
1943 ...	10,371	3,334	908	785	38,441	14,545	3,328	1,094	502,531	180,489	32,819	21,522
1944 ...	11,796	4,017	1,037	814	41,082	17,518	5,657	1,190	556,461	215,027	41,925	22,493
1945 ...	10,465	3,432	880	607	31,027	12,679	3,517	758	584,892	200,538	41,631	21,214
TOTAL ...	54,360	17,476	4,476	3,901	182,819	69,078	18,012	5,355	2,700,169	965,339	177,380	117,956
AVERAGE ...	10,872	3,495	895	780	36,564	13,816	3,602	1,071	540,034	193,068	35,476	23,591
1946 ...	9,335	2,700	588	534	26,866	9,874	1,660	648	516,897	185,993	33,557	19,003
1947 ...	10,583	3,122	604	876	29,500	10,280	1,513	420	568,044	201,615	41,399	25,458

Indian Journal of Malariology, **2**, *3, September 1948.*

ENGINEERING AND MAN-MADE MALARIA.

BY

LIEUT.-COLONEL JASWANT SINGH, M.B., Ch.B. (Edin.), D.P.H. (Eng.), D.T.M. & H. (Edin.).

(Director, Malaria Institute of India, Delhi.)

[October 25, 1948.]

IN some of the countries malaria has been successfully controlled, but here in India it is still the most important public health problem, constituting a major barrier to the development of the country as a whole. Apart from the colossal loss of life to the extent of over a million deaths a year, at least 100 million cases that suffer from this disease, and the financial loss in thousands of crores of rupees, there is the continued wastage of man-power and loss of efficiency in those that survive. In view of the immensity of the problem and in the absence of adequate means to combat malaria, the young India, i.e., infant and child population, chiefly in the vast rural areas is, so to say, continually being sacrificed.

Hitherto, majority of the engineering works have been completed without regard to the creation of permanent malariogenic factors or man-made malaria. The faulty conditions have been in the digging of borrow-pits, interference with natural drainage, defective irrigation systems and the like.

Since 1940, special courses in malariology for engineers were started by Major-General Sir Gordon Covell, at the Malaria Institute of India, with a specific object of imparting elementary knowledge of how malaria is caused, how it can be controlled and prevented by avoiding the formation of favourable breeding places of malaria-carrying mosquitoes, both during construction and thereafter. Apart from the lectures and demonstrations in the laboratories of the Malaria Institute of India, Delhi, during the one-week course, antimalaria engineering works in the Delhi Province are examined and their objects explained and discussed on the spot.

During 1940 and 1941, 87 engineers from different branches of the Public Works Departments of the Government of India, provincial governments, railways, etc., attended these courses but unfortunately during the following few years they had to be held in abeyance. Since 1946, they have been held every year and 24 engineers completed a course on the 23rd October, 1948.

In the national programmes of constructions of highways, railways, water and sewage works, hydro-electric, irrigation, water utilization and other multi-purpose projects, I consider it very essential that all engineers, before taking up their duties in this country, should receive adequate training at the Malaria Institute and become fully conversant with the fundamental principles of prevention and control of malaria that have such an important bearing on public health. In these fields engineers will have ample opportunities of analysing problems, utilizing their ingenuity in devising solutions, and applying all possible methods at the appropriate time with due regard to economy and needs of the malariologist. It is to be hoped that engineering departments of the governments concerned will ensure that as many engineers engaged on projects in malarious tracts as possible undergo such a course.

Indian Journal of Malariology, 2, 3, September 1948.

ABSTRACT OF

MALARIA SURVEY OF BIJAPUR DISTRICT.*

BY

S. H. GODBOLE,

T. RAMACHANDRA RAO,

AND

D. K. VISWANATHAN.

(*Malaria Organization, Bombay Province.*)

[June 3, 1948.]

A COMPREHENSIVE malaria survey of Bijapur District in Bombay Province was carried out from May 1947 to March 1948. Of the nine talukas in the district, malarial hyperendemicity was found to be prevalent only in Badami Taluka. Spleen rate in the 23 villages of this taluka varied from 5 to 96 per cent, only four villages showing a spleen rate under 10 per cent. In the remaining talukas malaria was focal, spleen rate in 99 villages varying from 0 to 50 per cent, and of these 67 villages were found to have spleen rates less than 10 per cent.

The parasite rate in the villages of Badami Taluka varied from 0 to 40 per cent while in those of the other 8 talukas range from 0 to 26 per cent. Of the 1,045 blood examinations for malaria parasites in Badami Taluka, 217 were found positive, 140 being *P. vivax*, 47 *P. malariæ* and the remaining 30 *P. falciparum*.

Seventeen anopheline species were encountered during the survey of which the three most important were *A. culicifacies*, *A. stephensi* and *A. fluviatilis*. As a result of the 3,453 mosquito dissections, *A. culicifacies* was found to be the chief vector with an infection rate of 0·26 per cent. One gland infection out of 980 specimens of *A. fluviatilis* and one gland infection in 1,272 specimens of *A. stephensi* were encountered.

---

* Copy of the original manuscript (29 pages with tables, and 13 references) has been placed in the library of the Malaria Institute of India, and is available on loan to workers who wish to consult it. (EDITOR).

Study of the egg measurements of *A. stephensi* in Badami Taluka indicated prevalence of the variety *mysoriensis* there.

The malaria season is described to be from July to December.

Indoor residual spray with D.D.T. is the method recommended in the control of malaria in this area. Recommendations regarding the staff and the financial implications in the proposed control scheme have been made.

Indian Journal of Malariology, 2, 3, September 1948.

INDIAN RESEARCH FUND ASSOCIATION.

No. 12/41/47-R.

FROM

THE SECRETARY,

GOVERNING BODY AND SCIENTIFIC ADVISORY BOARD,

INDIAN RESEARCH FUND ASSOCIATION.

To

ALL HOSPITALS IN INDIA.

New Delhi, the 30th July, 1948.

***Subject :*—Clinical trials of new remedies under the Indian Research Fund Association.**

DEAR SIR,

THE Governing Body of the Indian Research Fund Association has, on the advice of its Scientific Advisory Board, decided to establish under its auspices a 'Therapeutic Trials Committee' to sponsor and co-ordinate clinical research on new therapeutic agents. This Committee will encourage and aid impartial clinical trials of biological, chemotherapeutic and pharmaceutical agents of Indian or foreign origin, which offer promise in the prevention, treatment and diagnosis of diseases. The Medical Research Council of the United Kingdom and the Council of Pharmacy and Chemistry of the American Medical Association have set up similar bodies in their respective countries and it is considered that the time is now ripe for the initiation of such an organization in India also. The Committee constituted by the Scientific Advisory Board of the I.R.F.A. for the purpose is as follows :—

1. DR. M. G. KINI,
   Late Superintendent, Stanley Hospital, Madras.
2. DR. B. MUKERJI,
   Director, Central Drugs Laboratory, Calcutta.

3. LIEUT.-COLONEL JASWANT SINGH,
Director, Malaria Institute of India, Delhi.

4. DR. J. C. PATEL,
Honorary Assistant Physician, K.E.M. Hospital, Bombay (Secretary).

This Committee is empowered to co-opt other members as and when required and its functions will be :—

(*i*) to frame rules and regulations for the conduct of clinical trials ;

(*ii*) to obtain necessary information regarding facilities available in different institutions in India for this type of work. This information will be obtained through the Office of the Secretary, Indian Research Fund Association ;

(*iii*) to decide in the first instance on the suitability of any particular drug for clinical trials ; and

(*iv*) to collect data regarding suitability of the place and personnel who should be invited to undertake clinical trials of a particular type of drug.

The conditions under which the Indian Research Fund Association will be prepared to undertake clinical evaluation of new remedies of Indian or foreign origin submitted by the manufacturers, have been drawn up on the analogy of those adopted by the Medical Research Council of the United Kingdom and a copy of this is enclosed for your information. To carry out satisfactorily clinical trials of such agents the Association will naturally require the co-operation and help of all medical institutions in India which have facilities for such work and with this end in view I write to request you kindly to let me know at your earliest convenience whether your institution would be prepared to undertake clinical trials on behalf of the Indian Research Fund Association when asked to do so. It is requested in this connection that you would be so good as to fill in the attached questionnaire giving information under the various heads required by the Committee and send it to this office as soon as possible.

Yours faithfully,

T. GONSALVES,

for Secretary.

Facilities available in ....

....

for the conduct of clinical trials.

---

1. Name of institution :

---

2. Number of beds with the number of specialists and junior medical officers attached to each division.

(*a*) Medical :

(*b*) Surgical :

(*c*) Gynæcology and obstetrics :

(*d*) Ophthalmology :

(*e*) Chest diseases :

(*f*) Others :

---

3. Is there a separate children's hospital ?

---

4. Is there a separate dermatological ward ?

---

5. Number of beds that can be set apart in each ward for controlled clinical study without hampering the routine work.

---

6. Does the institution maintain an out-patients' department ? If so, the average attendance (monthly or weekly) and the types of cases treated may be stated.

---

7. (*a*) Is there a clinical diagnostic laboratory attached to the different hospital divisions ?

(*b*) Are there arrangements for post-mortem examination and pathological and bacteriological examinations ?

(*c*) Is there a separate laboratory for hæmatological and biochemical work of the hospital patients ?

(*d*) Indicate the special types of laboratory tests, e.g. liver function tests, kidney function tests, gastric test-meal analysis, B.M.R., etc., that are commonly undertaken in your hospital.

(*e*) Are there arrangements for pharmacological testing and determination of toxicity in laboratory animals of unknown medicinal agents ?

(*f*) Is there any arrangement for electro-cardiographic recording ?

(*g*) Is there any arrangement for radiological examination and physio-therapeutic applications ?

---

8. Is your institution recognized as a teaching centre ? If so, what is the number of members of the teaching staff in each department ?

---

9. Is it recognized for post-graduate training ? If so, what courses of study are offered ?

---

10. Is your institution prepared to undertake clinical trials on behalf of the Indian Research Fund Association ? If in the affirmative, please suggest names with qualifications of officers who wish to be on the panel. It may please be stated whether they have undertaken any work of this kind before and details of such work furnished.

---

11. State the facilities available in your institute for (*a*) clinical research and (*b*) basic research. Would the existing facilities, in your opinion, be adequate for the conduct of clinical trials or would further help be needed ? If so, a brief statement of the type of help that would be needed may please be given.

---

12. Is any research work being conducted at your institution with the aid of the funds of the Indian Research Fund Association or any other body or independently ?

Indian Journal of Malariology, **2**, *4*, *December 1948.*

OBITUARY.

FRANCIS HENRY SWINDEN CURD.

It is with deep regret that we have to record the death on December 2, 1948, of Dr. F. H. S. Curd of the Imperial Chemical Industries Limited.

Born in 1909, he received his early education at Bancrofts School, Woodford. He graduated in the honours school of chemistry in 1930 from the Queen Mary College, London. Until 1933 he collaborated in researches on the synthesis of compounds related to the lichen acids, for which he gained his Ph.D.

In 1933 he entered the research laboratories of Imperial Chemical Industries Limited at Blackley, Manchester, and like many other workers in the field of chemotherapy, served his apprenticeship on an investigation of the chemistry of dyestuffs. In 1936 he was seconded to the newly-formed Medicinal Chemicals Section, and for the next three years devoted his full attention to trypanosomiasis.

The outbreak of war caused this work to be interrupted, and Curd began the task of devising routes to the German synthetic anti-malarial drugs, Atebrin (Mepacrine) and Plasmochin (Pamaquin). Despite the lack of published information on preparative methods, these problems were solved in the early stages of war, and his work laid the foundation for a large-scale manufacture, particularly of 'Mepacrine' at that phase of the war when the drug was most urgently needed.

Experience with this substance indicated its shortcomings and Curd, with his colleagues, rapidly developed entirely new chemo-therapeutic types which resulted in the preparation, in 1944, of the

diguanide 'Paludrine'. For his part in this work, he was awarded in 1947, jointly with D. G. Davey and F. L. Rose, the Gold Medal for Chemotherapy of the Worshipful Society of Apothecaries.

More recently, Curd's attention had turned again to the problem of trypanosomiasis; and although he died before seeing the completion of his new work, there is little doubt that the outcome of his later researches, when fully revealed in the results of field-trials now in progress in Africa, will mark him as an outstanding figure in chemotherapeutic research.

Curd's personal attributes were known to a wide circle of friends in industry, universities and research institutions. He was a man with sterling qualities and his death robs chemotherapeutic research of one of its foremost workers, and at an age when his qualities were approaching full fruition. He leaves a widow and three young daughters. We offer our sincere sympathy to the bereaved family.

J. S.

Indian Journal of Malariology, 2, 4, December 1948.

ANOPHELES BREEDING IN THE RICEFIELDS OF LOWER BENGAL: ITS RELATION WITH THE CULTURAL PRACTICES AND WITH THE GROWTH OF RICE PLANTS.

BY

P. SEN, M.SC. (Cal.), Ph.D. (Lond.), D.I.C.
(*Entomologist, Directorate of Health Services, West Bengal.*)

[September 3, 1948.]

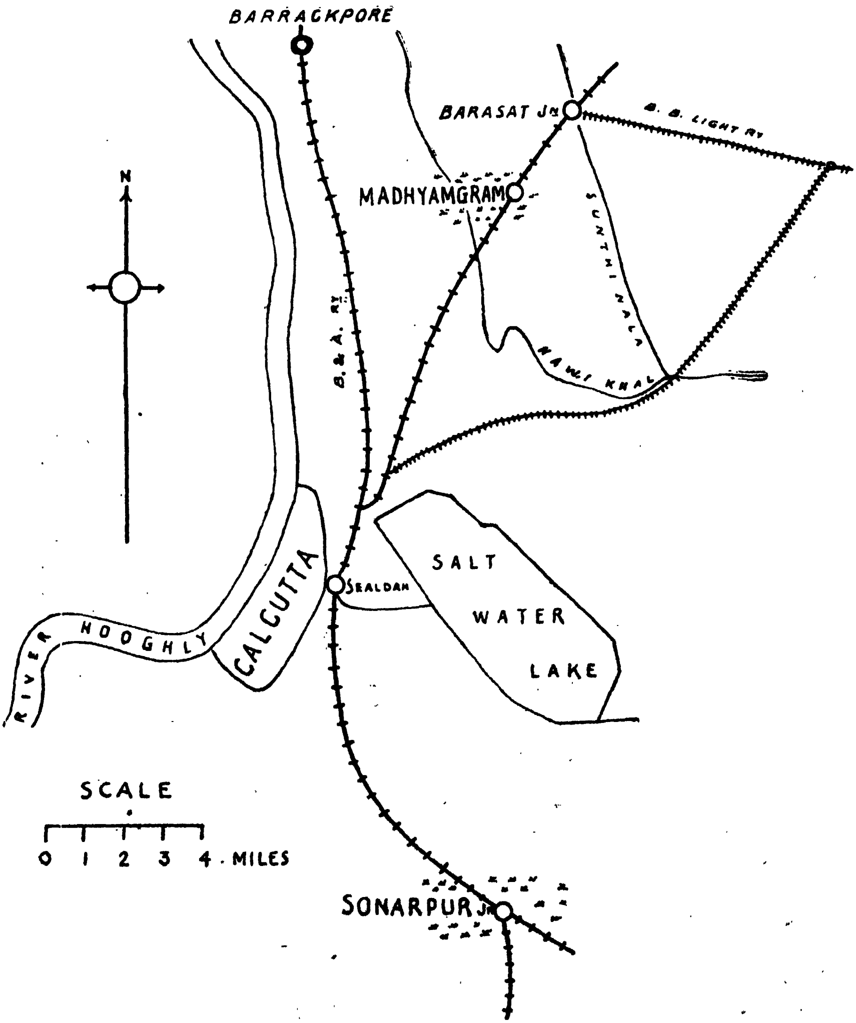
CONTENTS.

INTRODUCTION.

In a previous paper (Sen, 1935) it was shown that eleven species of Anopheles representing almost the entire group usually associated with the permanent water collections of the nearby locality were represented in the ricefield catches, and that the breeding of the vector species, especially *A. philippinensis*, was relatively sparse in the ricefields. It was further observed that numerically, as also in density of larvæ, the anopheline species behaved differently during the cultivation season. This difference in the behaviour was thought to be related to the progressive growth of the rice plants and the cultural practices followed in their cultivation or with the condition and depth of water which is so indispensable for the rice to grow. To evaluate the correctness of the above assumptions, the present study was undertaken in two differently situated zones, (1) Madhyamgram, a high-lying village with cultivations on the outskirts, and (2) Sonarpur, a low-lying area with cultivations in the centre. Both the places are within 10 to 12 miles of Calcutta but in different directions (Fig. 1).

FIG. I

SKETCH MAP SHOWING THE LOCATION OF THE RICEFIELDS STUDIED



DESCRIPTIVE.

At Madhyamgram, stagnation of water in the rain-fed ricefields was of a shorter duration and the fields dried up after October, while in Sonarpur, water remained in the fields until December. In the former place 61 rice plots were examined once a week from June to October, and in the latter 136 plots once a fortnight from July to December during two consecutive rice seasons.

The methods of cultivation and the quality of rice grown were the same in both the places. Usually with the first shower sometime in May or June, the soil is ploughed but transplanting is deferred till the onset of the regular monsoon in July. It is not unusual, therefore, for the fields to remain fallow for a few weeks from the time of ploughing until the monsoons commence.

ANOPHELES BREEDING AND FALLOW FIELDS.

In the fallow fields, both ploughed and unploughed, *A. vagus* was found breeding intensively. *A. subpictus* came next. These were the two main species that bred in the fields up till the time of transplanting.

Turbidity had no adverse effect on the larvæ of *A. vagus*. This factor, however, has been discussed in another chapter. There were a few casual records of *A. hyrcanus* var. *nigerrimus* from fallow fields but the species has a definite preference for cultivated fields with clean water.

ANOPHELES BREEDING AND CULTIVATED FIELDS.

In the cultivated fields at Madhyamgram, nine species (*A. vagus*, *A. subpictus*, *A. hyrcanus*, *A. barbirostris*, *A. annularis*, *A. ramsayi*, *A. philippinensis*, *A. pallidus* and *A. varuna*) in all were recorded (Table I). At Sonarpur, besides these nine species, *A. aconitus* and *A. tessellatus* were also found (Table II). The number of species found breeding at any one time increased as the year advanced with the peak in September.

The succession of anopheline species in ricefields incidental to changes in operational processes was well illustrated at Madhyamgram where in July, with the introduction of seedlings in the fields, *A. hyrcanus* and *A. annularis* followed *A. subpictus* and *A. vagus* which were still the commonest species in the fallow fields during June. This suggests that unless the silt has partially settled, *A. annularis* will not breed, and the breeding of *A. hyrcanus* is also greatly restricted. When the plants grow taller and the water in the fields becomes clearer, other important species like *A. pallidus*, *A. philippinensis* and *A. varuna* make their appearance.

In Sonarpur, on the other hand, this change-over of species was not so marked because during heavy rains the low-lying cultivated areas were more liable to be contaminated with certain extraneous anophelines from the village ponds which under such conditions become connected with the ricefields (Sen, 1941).

A. hyrcanus was the commonest species in the cultivated ricefields, and as a rule, this species prefers the late season. *A. philippinensis* occurred very rarely and never exceeded 1·0 per cent of the total collection in a month.

ANOPHELES BREEDING AND WATER CONDITION.

The effect of turbidity or clearness of water in the life of different anophelines in the ricefields is illustrated in Tables III and IV.

When the water is turbid owing to puddling in the transplanting season during the month of July, *A. vagus* and next to it *A. subpictus* breed in profuse numbers in the ricefields, but as mentioned above, with the settling down of the silt in the water, species like *A. annularis* and *A. hyrcanus* start breeding in earnest and so long as the water remains clear, more and more species appear (Fig. 2).

On the approach of the harvesting season, however, during October or November according to the situation of the fields, breeding of certain species such as *A. philippinensis* and *A. pallidus* is again adversely affected owing to water at the base of plants becoming polluted with rotting vegetation. Due to disturbed oxygen balance, the clean-water breeders find the conditions untenable. The numbers of *A. hyrcanus* and *A. annularis*, on the other hand, increased, these two species tolerating a certain amount of organic contamination.

ANOPHELES BREEDING AND WATER-COLUMN.

The ricefields studied showed the water-column varying from ½ inch to 2 feet 7 inches and anopheline larvæ were prevailing throughout the range (Table V). More often, however, fields were encountered with water table ranging from 2 inches to one foot, and anopheline incidence within this range was distinctly higher with an average of 4 larvæ per positive observation. Outside this range at both extremes, the number of fields were fewer and coincidently the anopheline incidence was also low with a frequency distribution of 2 to 3 larvæ approximately, excepting at ½ inch immediately after the early showers when *A. vagus* breeds profusely (Fig. 3). As mentioned above, this species prefers to breed in silty water and in fields without vegetation or shade. It ordinarily avoids water above one foot in depth.

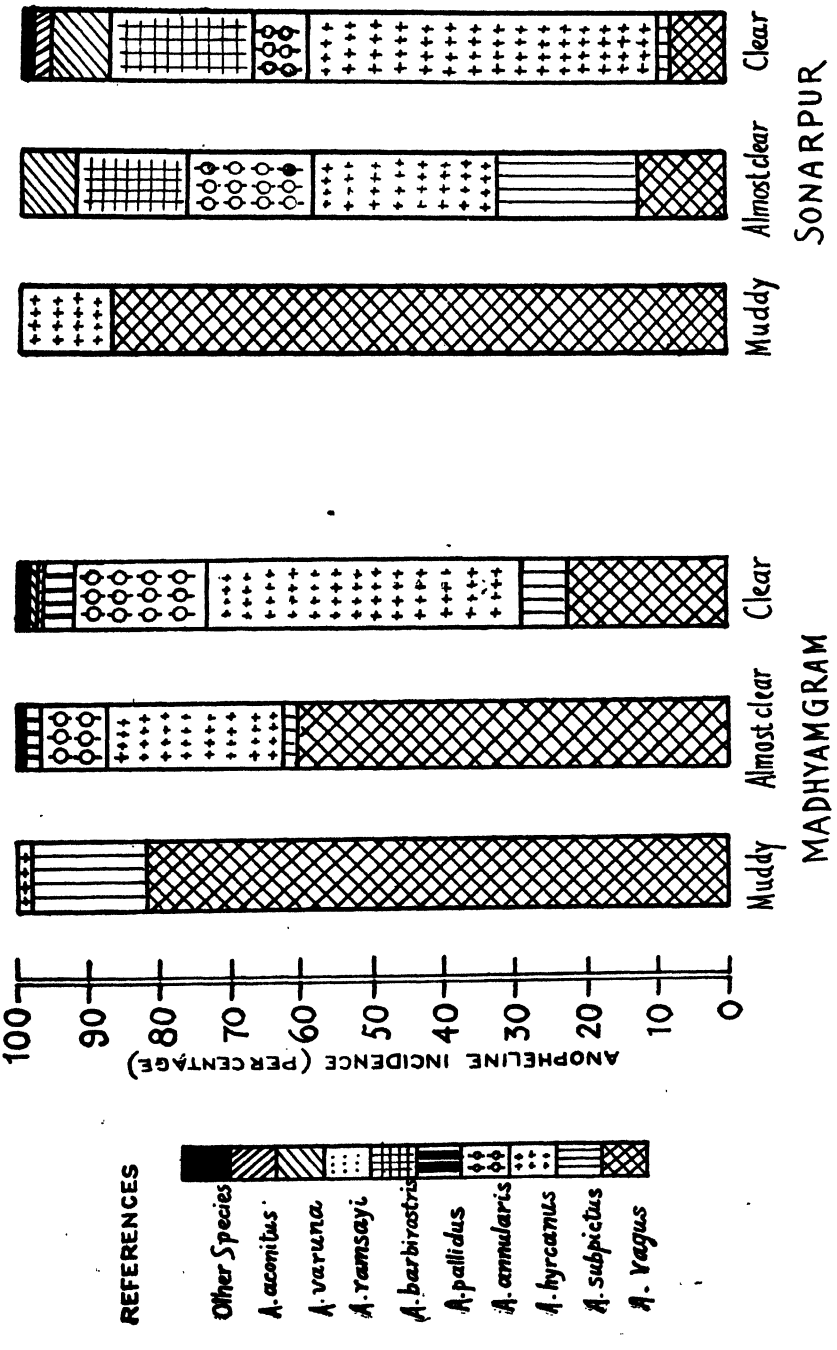
Apparently a very great depth of water is not preferred by the anophelines, possibly owing to the abundance of their natural enemies in deeper water or to other adverse environmental factors. The subject of natural enemies of mosquito larvæ and water composition will be discussed in detail in a later publication.

ANOPHELES BREEDING AND GROWING RICE PLANTS.

With the growth in the height of the rice plants, the various species of anophelines behaved differently (Table VI). When the plants had begun to grow and were about one foot tall and the water no longer so turbid, *A. annularis* and *A. ramsayi* were found in the fields along with the other two common species *A. subpictus* and *A. vagus*. With the plants reaching 15 inches in height, both *A. philippinensis* and *A. varuna* appeared, and with increased shade at 18 inches, two more species *A. pallidus* and *A. barbirostris* swelled the list indicating that they prefer deeper shade. After this, the anopheline species progressively declined

N.B.—All mention of *hyrcanus* refers to *hyrcanus* var. *nigerrimus*.

FIG. 2


Clear
Almost clear
Muddy
SONARPUR
Clear
Almost clear
Muddy
MADHYAMGRAM
100
90
80
70
60
50
40
30
20
10
0
ANOPHELINE INCIDENCE (PERCENTAGE)
REFERENCES
Other Species
A. aconitus
A. varuna
A. ramsayi
A. barbirostris
A. pallidus
A. annularis
A. hyrcanus
A. subpictus
A. vagus

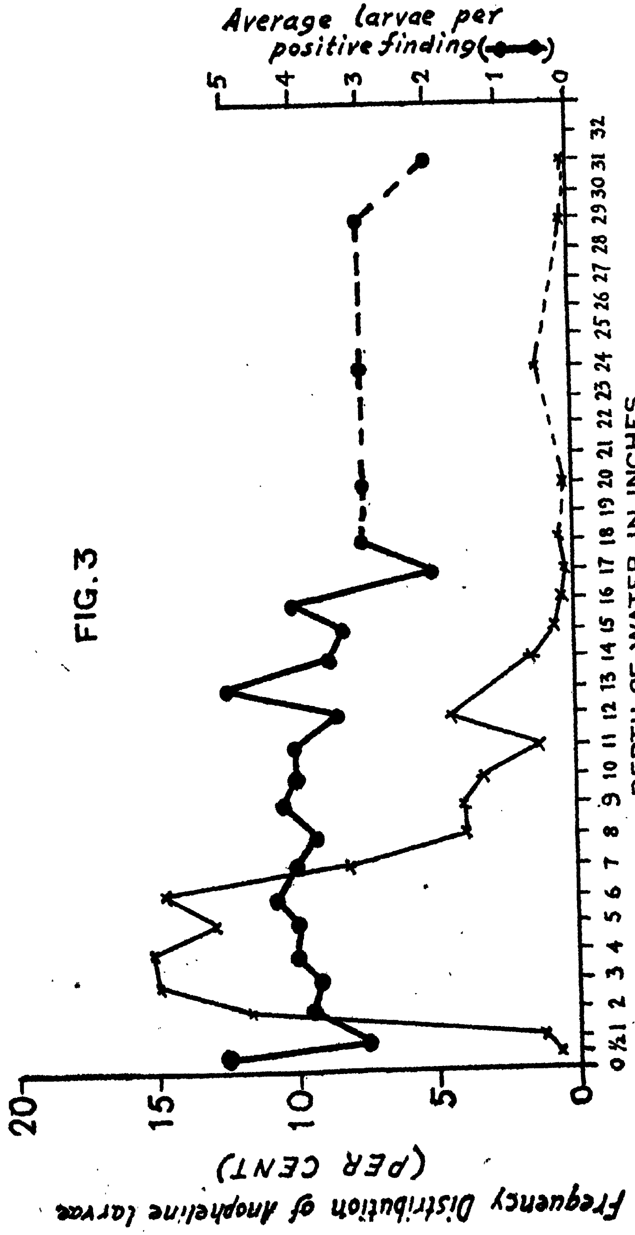
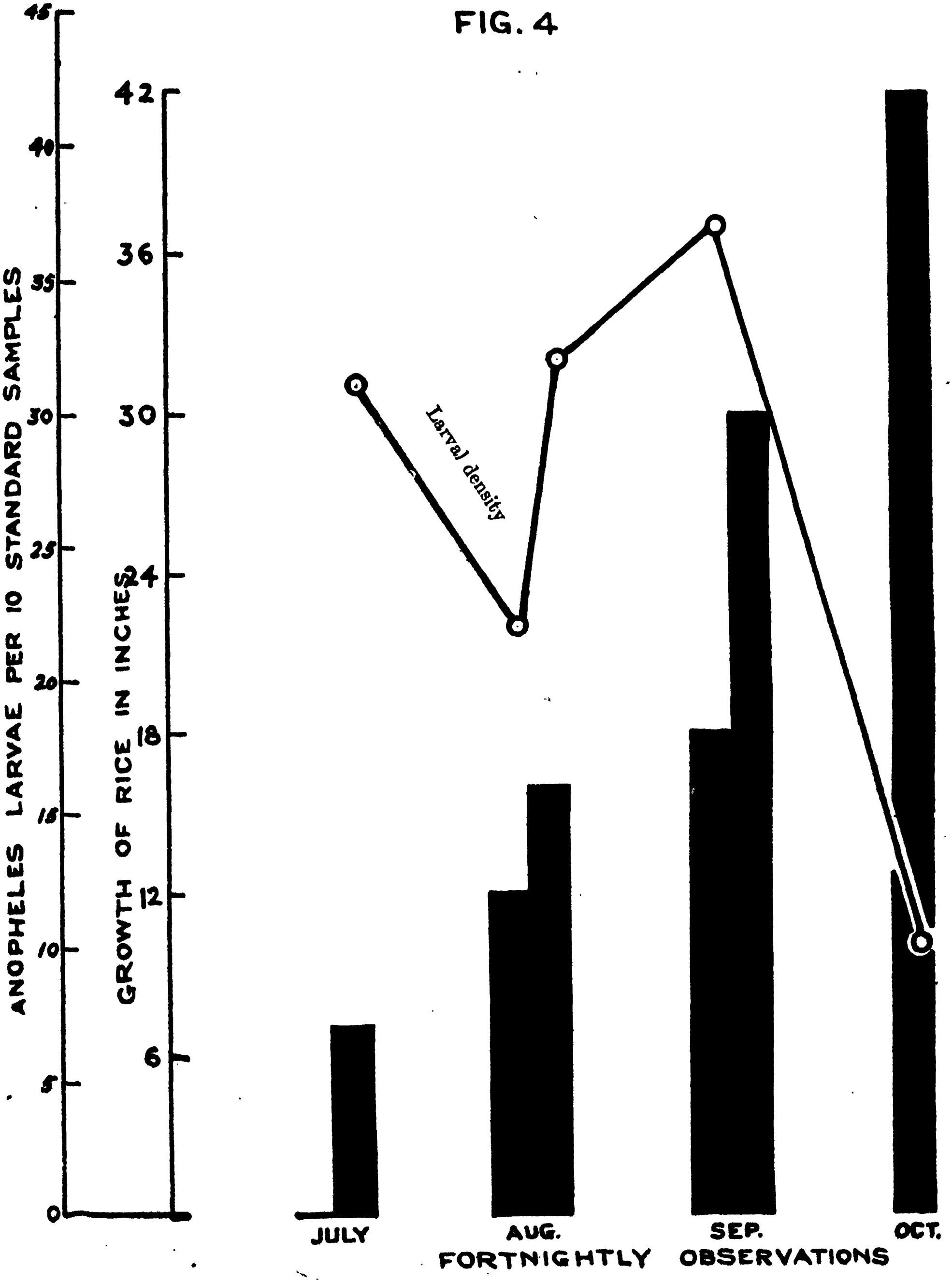

Average larvae per positive finding
5 4 3 2 1 0
DEPTH OF WATER IN INCHES
0 ½ 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
20 15 10 5 0
(PER CENT)
Frequency Distribution of Anopheline larvae

FIG. 3

FIG. 4


ANOPHELES LARVAE PER 10 STANDARD SAMPLES
45
40
35
30
25
20
15
10
5
0
GROWTH OF RICE IN INCHES
42
36
30
24
18
12
6
Larval density
JULY
AUG.
SEP.
OCT.
FORTNIGHTLY OBSERVATIONS

in number in the ricefields. When the plants reached 2 feet stage towards the latter part of September, *A. philippinensis*, *A. ramsayi* and *A. subpictus* disappeared, and still later at 3½ feet height of the plants during October, the ricefields possessed no other species excepting the two commonest *A. hyrcanus* and *A. annularis*. At this time of the year, however, nearly 40 per cent of the ricefields dry up, and as already mentioned, the water in the rain-fed fields becomes highly stagnated.

The Anopheles output in relation to the different stages of the plants has been graphically represented in Fig. 4. At Madhyamgram, with the increase in the height of plants, the density of anophelines increased from 3 per catch in July to 4 in September; after which there was an abrupt fall to 1 during October.

DISCUSSION.

The observations recorded above reveal that the more important species like *A. philippinensis* (the vector species), *A. pallidus* and *A. varuna* appeared in the ricefields only after the plants have grown 12 to 18 inches in height to afford some shade. Water table by this time showed an index of 2 inches or more, and of course, the water was no longer turbid or muddy. The species were not seen in fallow fields nor after the plants have attained a certain height, 2 feet in case of *A. philippinensis*, and in the other two species 2½ feet or 2¾ feet which meant only a limited span of infestation.

Most species including *A. philippinensis* do not breed in ricefields during the transplanting season when the water is silt-laden. The detrimental effect of silt on the life of vector species has been observed by others also, for instance, *A. sundaicus*, the well-known vector, will not breed in fields with silty water (Senior White, 1946), and in East Bengal this factor has been responsible for the reputed immunity from malaria of a large tract (Swellengrebel, 1933). Equally interesting is the habit of *A. hyrcanus* (*sinensis*), a local vector in China, in colonizing the ricefields with the disappearance of silt (Robertson and Chang, 1937) just in common with its Indian form (*nigerrimus*) discussed elsewhere.

In confirmation of the previous finding by the present author (Sen, 1935), the ricefield breeding of *A. philippinensis*, the only natural vector in the areas of study, was again found to be very small compared to that in the village ponds overgrown with aquatic weeds. In village ponds, the relative frequency of *philippinensis* was 10·6 in 10 standardized samples (Sen, 1941) as against 0·3 in the ricefields now studied; in other words, the breeding of the species in ponds was over 35 times as much as in the ricefields. Similar observations were made by Purdy (1920) in Californian ricefields where for every mosquito produced by the ricefields, there were 44 produced by the natural ditches. The permanent water collections within the village are thus much more dangerous. Two other vectors of Bengal malaria, *A. sundaicus* in the tidal zones of lower Bengal and *A. minimus* in the terai of northern Bengal (and of Assam) do not also normally find ricefields suitable for their development (Senior White, 1946; Thomson, 1940).

This should allay all suspicion, at least in Bengal, that the ricefields everywhere are congenial to malaria. On the contrary, it would be advantageous to encourage more cultivation (especially in view of the country-wide shortage of

food grains). In fact, Strickland and Gibson (1934) successfully eliminated *A. minimus* and *A. philippinensis* breeding from a certain area in Assam by introducing rice.

The breeding of the anophelines in fields with growing rice plants seems to differ in the various rice-growing countries. In Siam, *A. barbirostris*, the only species in the ricefields, breeds in association with young rice plants (Causey, 1937); in Bengal this species is associated with plants of about 1½ feet or more in height indicating that the species prefers to breed with fairly developed plants. *A. pallidus* appears in Bengal fields only after the plants are 16 inches tall when they are capable of affording good shade, while in South-East India the species has been found to decline with shade (Russell and Rao, 1940). This species, however, did not go beyond 2½ feet stage of rice which was about one foot short of the harvesting height.

If distinct biotypes are not involved, of which very little information is available at the moment, such behaviouristic conflicts, although bewildering at first sight, yield particularly well for an explanation to the mode of cultivation and the variety of rice grown which differ, not only in the various countries but also inside the same country from place to place. Where the fields are canal-irrigated, as in South-East India, the breeding potentiality of clean cool-water breeders like *A. pallidus* would naturally differ from their counterpart in the static rain-fed fields of Bengal for the obvious reason that a new factor of water circulation (with all its implications) is introduced by irrigation.

The significance of growing rice plants is to afford shade which affects the life of anophelines in two ways, (1) by influencing the breeding indirectly through its control over water temperature, and (2) by regulating the growth of plankton especially algæ.

(1) *Temperature.*—Thomson (1940) has already stressed on the restricting effect of temperature on the life of anophelines, particularly *A. minimus*, in the ricefields of Assam. The restricted breeding of *A. philippinensis* in Bengal fields also appears to depend on this factor to a great extent. Towards the beginning of cultivation when the shade is not sufficiently formed, the temperature of the water in a ricefield often reaches 42°C. or above at 3 p.m. on clear days, and is beyond the tolerance limit of the species. At such high temperatures, species like *A. hyrcanus* (43°C.) or *A. vagus* (44°C.) can only survive.

When Ramsay and MacDonald (1936) suggest, and very aptly too, that *A. philippinensis* does not breed in shallow pools fully exposed to the sun nor in absence of aquatic vegetation, they, in fact, contribute to the view now propounded that the water temperature which in turn depends on the sun is a great limiting factor. Iyengar, as quoted by Covell (1944), while agreeing on the necessity of submerged vegetation in providing breeding facility to the species, however, thinks notwithstanding the observations of Ramsay and MacDonald, that *A. philippinensis* prefers ponds exposed to sunshine, and cutting off of sunlight is inhibitory to its breeding. The difference in the statements of the authors is understandable. The shallow pools without vegetation, of which Ramsay and his colleague speak, under the tropical sun readily get sufficiently warmed up for most anophelines to survive. On the other hand, in the deeper ponds with subsoil water and shaded by aquatic

vegetation, the sunshine not only is incapable of raising the water temperature high enough to restrict the breeding of the species but this does definite good by promoting the growth of the phytoplankton, particularly algæ, the rôle of which on the life of anophelines is discussed below.

(2) *Algæ*.—Importance of algæ in the production of anophelines has been long recognized, and Sen (1941) has already discussed on the close association of *A. philippinensis* breeding and *Spirogyra*. The growth of filamentous algæ which are of such vital importance to the life of anophelines is greatly affected by the absence of sunlight or by shade due to the growing rice plants. Under partial shade, when the plants are small, *Spirogyra* and a few non-filamentous algæ are seen in the ricefields. But with the gradual increase in shade, there is always a reduction in algæ which become scarce beyond 2½ feet stage of rice plant and this naturally implies a decrease of larvæ (especially *A. philippinensis*) as has also been the experience of Sokolov (1941).

SUMMARY.

1. Eleven species of anophelines (*A. hyrcanus* var. *nigerrimus*, *A. barbirostris*, *A. annularis*, *A. ramsayi*, *A. pallidus*, *A. philippinensis*, *A. tessellatus*, *A. varuna*, *A. aconitus*, *A. vagus* and *A. subpictus*) were recorded from the ricefields.

2. The anophelines, excepting *A. vagus* and *A. subpictus*, avoid turbid or muddy water.

3. *A. hyrcanus* and *A. annularis* appeared in the ricefields with the introduction of seedlings, but they bred more intensively towards the close of the rice season when the water had stagnated.

4. The anophelines prefer to breed within a range of 2 to 12 inches of water in the cultivated ricefields. They avoid deeper water.

5. With the water table as above, rice plants one to two feet in height provide the best range for development of most anophelines. *A. philippinensis* (the vector species), *A. pallidus* and *A. varuna* indicated preference for breeding in fields with plants usually between 15 and 18 inches in height affording deep shade.

6. The rice plant through its shade controls the breeding of anophelines that matter, especially *A. philippinensis*, by influencing the water temperature which reaches 42°C. or above in the afternoon on clear days, and by regulating the growth of plankton, especially *Spirogyra*, which is reduced in dense shade.

7. Only *A. hyrcanus* and *A. vagus* can withstand the high temperatures indicated above.

8. The sparse breeding of *A. philippinensis* in the ricefields, and the immunity of rice in the causation of malaria in the areas studied, are discussed.

ACKNOWLEDGMENT.

The first impulse to investigate the ricefield breeding from the aspects herein discussed came from Major Senior White to whom the author is greatly indebted.

The author also wishes to record his thanks to Field Assistant J. C. Biswas for his valuable assistance in carrying out the field observations.

REFERENCES.

Causey, O. R. (1937) ... Some anopheline and culicine mosquitoes of Siam with remarks on malaria control in Bangkok. *Amer. J. Hyg.*, **25**, pp. 400–420.

Covell, G. (1944) ... Notes on the distribution, breeding places, adult habits and relation to malaria of the anopheline mosquitoes of India and the Far East. *J. Mal. Inst. Ind.*, **5**, pp. 399–434.

Purdy, W. C. (1920) ... Biological investigations of Californian ricefields relative to mosquito breeding. *U.S.A. Pub. Hlth. Rpts.*, **35**, pp. 2556–2570.

Ramsay, G. C., and MacDonald, G. (1936). The species control of anophelines in India. *Ind. Med. Gaz.*, **71**, pp. 699–710.

Robertson, R. C., and Chang, T. (1937). Rice cultivation in relation to malaria. *China J.*, **26**, pp. 347–360. [*R.A.E.* (B), **26**.]

Russell, P. F., and Rao, H. R. (1940). The Anopheles of ricefields in south-eastern Madras. *J. Mal. Inst. Ind.*, **3**, pp. 427–446.

Sen, P. (1935) ... ... Anopheles breeding in relation to rice cultivation in lower Bengal. *Rec. Mal. Surv. Ind.*, **5**, pp. 97–108.

Idem (1941) ... ... Aquatic plants in the ecology of anopheline mosquitoes. *J. Mal. Inst. Ind.*, **4**, pp. 113–137.

Senior White, R. (1946) ... Anopheline breeding in ricefields. *J. Mal. Inst. Ind.*, **6**, pp. 437–468.

Sokolov, N. P. (1941) ... Influence of sun radiation on the distribution of Anopheles *hyrcanus* larvæ under conditions of ricefields. *C. R. Acad. Sci. URSS.* (N.S.), **33**, pp. 166–169. [*R.A.E.* (B), **31**.]

Strickland, C., and Gibson, D. (1934). 'Backdoor drainage,' an antimalarial measure designed to meet a particular physiological situation in Sylhet District, Assam. *Ind. Med. Gaz.*, **69**, pp. 432–437.

Swellengrebel, N. H. (1933) ... Malaria in Deltas. Studies on malaria in the Rhine Delta. *Riv. Malariol.*, **12**, pp. 953–979.

Thomson, R. C. M. (1940) ... Studies on the behaviour of *Anopheles minimus*. Part III. The influence of water temperature on the choice and suitability of the breeding place. *J. Mal. Inst. Ind.*, **3**, pp. 323–348.

TABLE I.

Anopheline larvæ from cultivated fields, Madhyamgram.

Months.	*hyrcanus.*	*barbirostris.*	*annularis.*	*ramsayi.*	*pallidus.*	*philippinensis.*	*subpictus.*	*vagus.*	*varuna.*
Jul. ...	2·7	...	3·4	...	...	...	4·8	88·9	...
	0·8	...	1·0	...	...	...	1·5	27·4	...
Aug. ...	20·9	...	11·6	...	2·3	...	2·9	61·6	0·6
	8·6	...	4·8	...	1·0	...	1·2	25·2	0·2
Sep. ...	51·9	0·7	17·4	1·1	5·1	0·6	8·0	13·6	1·3
	28·0	0·3	9·4	0·6	2·7	0·3	4·3	7·3	0·7
Oct. ...	52·5	2·5	35·0	5·0	...	...	...	2·5	2·5
	13·1	0·6	9·0	1·2	...	...	...	0·6	0·6

Upper figures = percentage of total collections.
Lower figures = numerical abundance per 10 standardized samples.

TABLE II.

Anopheline larvæ (percentage) from cultivated fields, Sonarpur.

Months.	*hyrcanus.*	*barbirostris.*	*annularis.*	*ramsayi.*	*philippinensis.*	*subpictus.*	*vagus.*	*varuna.*	*aconitus.*	*pallidus.*	*tessellatus.*
Jul.	30·7	15·1	10·3	0·1	0·2	18·5	18·2	6·5	0·3	...	...
Aug.	46·0	15·8	7·7	0·4	0·5	4·9	7·6	15·4	1·2	0·3	...
Sep.	33·5	42·7	4·6	0·6	...	...	1·7	15·0	0·6	...	1·1
Oct.	60·5	13·4	7·0	0·8	0·4	...	9·2	5·6	3·0	...	...
Nov.	47·0	20·2	9·4	0·2	0·1	0·2	9·2	9·5	4·0	...	...
Dec.	58·7	22·9	7·2	0·7	0·1	0·1	1·9	4·5	3·8	...	...

TABLE III.

Relative frequency of anopheline larvæ according to the nature of water in ricefields.

(Madhyamgram.)

Nature of water.	Number of examinations.	Number of positive findings.	Total larvæ.		*hyrcanus.*	*barbirostris.*	*annularis.*	*ramsayi.*	*pallidus.*	*philippinensis.*	*subpictus.*	*vagus.*	*varuna.*
Muddy	26	19	50	Percentage ...	2·0	...	...	...	...	...	16·0	82·0	...
				Per 10 standardized samples.	0·5	...	...	...	...	...	4·2	21·5	...
Almost clear* ...	44	40	231	Percentage ...	25·5	...	9·1	0·4	1·7	...	1·7	60·6	0·8
				Per 10 standardized samples.	14·7	...	5·2	0·2	1·0	...	1·0	35·0	0·5
Clear	128	98	523	Percentage ...	44·5	0·7	18·3	1·1	4·4	0·6	6·8	22·2	1·1
				Per 10 standardized samples.	23·7	0·4	10·0	0·6	2·3	0·3	3·6	11·6	0·6

* When the water does not show muddy appearance, but is not yet transparent.

TABLE IV.

Relative frequency of anopheline larvæ according to the nature of water in ricefields.

(Sonarpur.)

Nature of water.	Number of examinations.	Number of positive findings.	Total larvæ.		*hyrcanus.*	*barbirostris.*	*annularis.*	*ramsayi.*	*philippinensis.*	*pallidus.*	*subpictus.*	*vagus.*	*varuna.*	*aconitus.*	*tessellatus.*
Muddy ...	12	8	16	Percentage ...	12·5	...	...	...	...	...	...	87·5	...	...	...
				Per 10 standardized samples.	2·5	...	...	...	...	...	...	17·5	...	...	...
Almost clear.*	42	31	77	Percentage ...	26·4	15·7	17·8	...	...	...	20·0	12·7	7·3	...	...
				Per 10 standardized samples.	5·6	3·6	4·0	...	...	...	5·8	2·7	1·8	...	...
Clear ...	1,044	867	3,642	Percentage ...	51·2	20·2	7·4	0·2	0·4	0·04	0·9	8·0	8·5	2·9	0·05
				Per 10 standardized samples.	21·3	8·3	3·0	0·2	0·2	0·02	0·4	3·4	3·4	1·2	0·03

* When the water does not show muddy appearance, but is not yet transparent.

TABLE V.

Ricefield breeding at different depths.

Depth of water, inches.	½	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	24	29	30	31
Number of examinations.	7	42	208	273	228	193	186	119	82	59	45	25	75	5	23	12	3	1	8	2	19	2	1	1
Number of positive findings.	5	18	155	206	193	163	174	104	53	46	42	17	67	4	21	10	3	1	7	2	19	2	...	1
Total larvæ collected.	27	52	595	771	785	663	756	414	199	194	170	62	226	20	73	33	11	2	22	6	56	6	...	2
Larvæ per positive findings.*	5	3	4	4	4	4	4	4	4	4	4	4	3	5	3	3	4	2	3	3	3	3	...	2

* Fractions above 0·5 approximated to the next higher whole number, 0·5 and below with the whole number on wrong side.

TABLE VI.

Relative frequency of anopheles larvæ in the ricefields of Madhyamgram at different heights of the rice plant.

Height of plants* (inches).	Number of examinations.	Number of positive findings.	Total larvæ.	Species recorded.
6	11	6	32	*vagus.*
7	18	11	56	*annularis, subpictus, vagus.*
8	10	5	16	*hyrcanus, annularis, vagus.*
9	4	2	15	*vagus.*
10	4	4	55	*subpictus, vagus.*
12	6	2	13	*annularis, ramsayi, subpictus, vagus.*
14	4	3	18	*annularis, vagus.*
15	6	5	38	*hyrcanus, annularis, philippinensis, vagus, varuna.*
16	12	8	39	*hyrcanus, annularis, ramsayi, pallidus, subpictus, vagus, varuna.*
17	15	11	73	*hyrcanus, annularis, barbirostris, pallidus, subpictus, vagus.*
18	24	19	72	*hyrcanus, barbirostris, annularis, pallidus, vagus, varuna.*
19	8	6	39	*hyrcanus, annularis, ramsayi, philippinensis, vagus.*
20	12	8	50	*hyrcanus, annularis, subpictus, vagus.*
21	2	2	12	*hyrcanus, barbirostris, annularis, pallidus.*

* Height above water level.

TABLE VI—*concld.*

Height of plants* (inches).	Number of examinations.	Number of positive findings.	Total larvæ.	Species recorded.
22	7	6	34	*hyrcanus, annularis, philippinensis, pallidus.*
24	6	5	33	*hyrcanus, annularis, varuna.*
26	3	3	14	*hyrcanus, annularis.*
27	3	3	13	*hyrcanus, annularis, pallidus.*
29	2	2	11	*hyrcanus, barbirostris, annularis, pallidus.*
30	8	7	26	*hyrcanus, barbirostris, annularis, pallidus.*
33	2	2	4	*hyrcanus, annularis, varuna.*
36	3	1	10	*hyrcanus, annularis, vagus.*
39	2	2	5	*hyrcanus, annularis.*
42	4	2	4	*hyrcanus, annularis.*

* Height above water level.

Indian Journal of Malariology, **2**, 4, December 1948.

RECORDS OF NATURAL INFECTIVITY OF ANOPHELES IN WEST BENGAL.

BY

P. SEN, M.SC., Ph.D. (Lond.), D.I.C.
(*Entomologist, Directorate of Health Services, West Bengal.*)

[November 24, 1948.]

INTRODUCTION.

INSTANCES of natural infection in certain species of Anopheles in Bengal have been reported from time to time (Iyengar, 1931, 1939 and 1940; Sen, 1938 and 1938*a*; Sur, 1928). In the present paper some more instances are recorded mostly from areas not so far reported. The species involved are, however, all established vectors of malaria, viz., *A. sundaicus*, *A. philippinensis* and *A. minimus*. The observations discussed here are not the outcome of any special investigation but they came up in course of routine antimalarial work, and these may, therefore, appear at places incoherent or without any chronological sequence.

INFECTION IN *A. SUNDAICUS*.

This species has been of widespread occurrence in the region immediately to the south and east of Calcutta including the salt lakes (Sen, 1938*a*) which were put under larval control for over 15 years. In spite of this, good catches were obtained almost every year from the areas and the adults dissected often revealed natural infectivity in the species. The results of dissections during the years 1933–1937 are given in Table I.

The dissections reveal that infections in *A. sundaicus* take place during the months July–December, and the maximum infectivity is reached in August and September. With the approach of winter it drops in November. Iyengar's (1940) records of 20 per cent infection rate in August and nil in December, although the number dissected was small, give corroboratory evidence to the present findings.

TABLE I.

Infectivity rate in A. sundaicus, 1933–1937.

Year of dissection.	Month.	Number dissected.	Number positive.	Infectivity rate per cent.	Locality.
1933	Aug. ...	30	3	10·0	Fuleswar (Howrah).
1934	Jul. ...	15	1	6·6	Nebutola (Calcutta).
	Aug. ...	28	1	3·6	Shamnagar (24 Perganas).
1936	Aug. ...	21	2	9·5	Belgatchia (Shambazar train importation).
	Nov. ...	124	4	3·2	Dhapa (Salt lakes).
	Dec. ...	17	1	5·8	Dhapa (Salt lakes).
1937	Sep. ...	138	17	12·3	Goalbari (Salt lakes).
	TOTAL ...	373	29	7·7	

Other records of infections in this species of Iyengar (1931, 1940), Ghose (unpublished) and Sen (1938) are tabulated below (Table II) :—

TABLE II.

Other records of infection in A. sundaicus.

Author.	Year of dissection.	Month.	Number dissected.	Number positive.	Infection rate per cent.	Locality.
Iyengar (1931) ...	1930	Oct.–Nov. ...	838	196	23·4	Industrial areas at Budge Budge.
		Nov. ...	71	3	4·2	Chengail (Howrah).
Idem (1940) ...	1936	Aug. ...	15	3	20·0	Patuakhali (East Bengal).
Ghose (unpublished)	1931	?	?	?	7·0	Majherat (Train Coll.).
Sen (1938) ...	1936	Nov. ...	124	4	3·2	Dhapa (Salt lakes).

INFECTION IN *A. PHILIPPINENSIS.*

At Madhyamgram (24 Perganas) about 10 miles to the east of Calcutta, *A. sundaicus* infection stops, and the cue is taken up by *A. philippinensis.* Similarly the vectorial status of *A. sundaicus* is not known to have been pushed beyond Shamnagar (24 Perganas) on the upper reaches of the Hooghly (Table I).

The results of dissection of *A. philippinensis* at Madhyamgram in the year 1936, when the malaria incidence in the village was high, are shown in Table III.

TABLE III.

Infectivity rate in A. philippinensis, 1936.

Month.	Number dissected.	Number positive.	Infectivity rate per cent.
Jun. ...	28	1	3·6
Jul. ...	93	4	4·3
Aug. ...	31	5	16·1
Sep. ...	5	1	20·0
Oct. ...	7	*nil.*	0·0
Dec. ...	16	1	6·2
TOTAL ...	180	12	6·6

The above results show that *A. philippinensis* is capable of carrying the infection from June to December, and the maximum harm is done by it during August and September. In this respect there seems to be a remarkable comparison between the two species, *A. sundaicus* and *A. philippinensis.* With the drop in temperature during December, the activity of the latter species is however considerably curbed.

Other records of infection in *A. philippinensis* reported from areas within West Bengal are tabulated in Table IV.

TABLE IV.

Other records of infection in A. philippinensis.

Author.	Year of dissection.	Months.	Number dissected.	Number positive.	Infection rate per cent.	Locality.
Bose (1932) ...	1931	Sep.–Nov. ...	499	11	2·2	Birnagar (Nadia).
Iyengar (1939) ...	1937-38	Nov.–Oct.	403	29	7·2	Ilambazar (Birbhum).
			879	101	11·5	Arambagh (Hooghly).
Idem (1940) ...	1938	Jan.–Dec. ...	142	22	15·5	Adiganga (Sonarpur, 24 Perganas).
	1939	Mar.–May and Sep.–Nov.	914	59	6·5	Chandrakona (Midnapore).
Krishnan (1940) ...	1939	All months	1,053	89	7·5	Abujhati (Burdwan).
Sur (1928) ...	1927	Oct.–Nov.	223	7	3·1	Krishnagar (Nadia).
Sur and Sur (1929) ...	1927-28	All months	762	15	1·9	Krishnagar villages.
Timbers (1935) ...	1932–34	All months	12,594	131	1·04	Bolpur Thana (Birbhum).

Iyengar's (1940) record of *A. philippinensis* infection in some locality within Adiganga area was from right in the heart of *A. sundaicus* zones. It is a remarkable instance how obliteration of salt marshes and receding of tidal influence, as happened in this zone of late, changed the vectorial position of the area. The *A. sundaicus* foci which at one time appeared to be of such great importance, are practically non-existent now.

INFECTION IN *A. MINIMUS*.

The vectorial status of the species was gauged from a single collection at Dam Dim (Jalpaiguri) in a tea estate on the submontane region of the province. The results of dissection of the species are shown in Table V.

TABLE V.

Infectivity rate in A. minimus, 1942.

Month.	Number dissected.	Number positive.	Infection rate per cent.
Sep. ...	17	1	5·9

Other records of infectivity in the species are shown in Table VI.

TABLE VI.

Other records of infection in A. minimus.

Author.	Year of dissection.	Months.	Number dissected.	Number positive.	Infection rate per cent.	Locality.
Iyengar (1939) ...	1937-38	Nov.–Oct.	719	43	6·0	Naksalbari (Darjeeling).
Idem (1940) ...	1936	Jun.-Jul.	172	32	18·6	Naksalbari (Darjeeling).
Niogi and Khan (1937).	1930–35	All months	8,385	513	6·1	Dooars (Jalpaiguri).

The results reported in Tables V and VI will show that *A. minimus* is responsible for malariousness of the foot-hill terai land in the north, and is the chief scourge in the tea estates there.

RESULTS OF DISSECTION WITH OTHER SPECIES.

Ten other species of Anopheles commonly met with in our routine surveys in Calcutta and outlying areas including the salt lakes were dissected during the

years 1933–1940, but none of them showed any infection with malaria parasites, and the number examined of each species is shown below :—

A. annularis	...	...	...	1,721
A. ramsayi	...	...	...	140
A. pallidus	...	...	...	28
A. hyrcanus	...	...	...	610
A. barbirostris	...	...	...	80
A. varuna	...	...	...	259
A. aconitus	...	...	...	80
A. subpictus	...	...	...	1,564
A. vagus	...	...	...	137
A. stephensi	...	...	...	19

Out of this list, infections of a mild character have been encountered in *A. varuna* (Iyengar, 1940; Roy, 1939), *A. pallidus* (Iyengar, 1939) and *A. stephensi* (Siddons, 1946), in parts of West Bengal, the rate never attaining even 1·0 per cent. More work is needed to establish the status of these species finally in the epidemiology of the greater Calcutta.

SUMMARY.

1. Infectivity in *A. sundaicus* has been recorded from Calcutta and its environs including the salt lakes during July to December. The incidence of infection was on an average 7·7 per cent, and varied in the different months.

2. Infected specimens of *A. philippinensis* were found in Madhyamgram about 10 miles to the east of Calcutta during the months June to December 1936. The average infection rate was 6·6 per cent with monthly variations; the maximum was reached in August and September.

3. Infectivity in *A. minimus* was detected in a single collection from the tea gardens at Dam Dim (Jalpaiguri) in the submontane zone during September 1942, and the rate of infection was 5·9 per cent.

4. Ten other common species dissected for malarial infection proved negative.

REFERENCES.

Bose, K. (1932) ... ... Confirmation of *A. philippinensis* as a malaria carrier in Bengal. *Rec. Mal. Surv. Ind.*, **3**, pp. 161-162.

Ghose, B. (unpublished) ... Departmental Reports, Director of Public Health, Bengal, Calcutta.

Iyengar, M. O. T. (1931) ... The distribution of *Anopheles ludlowii* in Bengal and its importance in malarial epidemiology. *Ind. J. Med. Res.*, **19**, pp. 499–522.

Idem (1939) ... A year's work on dissection of Anopheles for natural malarial infection. *J. Mal. Inst. Ind.*, **2**, pp. 105–109.

Idem (1940) ... Further observations on vectors of malaria in Bengal and notes on the seasonal infectivity of Anopheles. *J. Mal. Inst. Ind.*, **3**, pp. 115–123.

KRISHNAN, K. V. (1940) ... Report of the Professor of Malariology and Rural Hygiene. *Annual Report of the All-India Institute of Hygiene and Public Health, Calcutta,* 1939. Govt. of India Press, Calcutta, pp. 32–36.

NIOGI, S. K., and KHAN, B. M. (1937). Winter malaria infection in the Bengal Dooars. *Rec. Mal. Surv. Ind.*, **7**, pp. 213–219.

ROY, D. N. (1939) ... ... The importance of *A. varuna* as a carrier of malaria in Bally, Calcutta. *J. Mal. Inst. Ind.*, **2**, pp. 239–242.

SEN, P. (1938) ... ... *Anopheles sundaicus* (*ludlowi*) and malaria in Calcutta. *J. Mal. Inst. Ind.*, **1**, pp. 83–98.

Idem (1938*a*) ... ... *Anopheles ludlowii* (*A. sundaicus*) survey in and around Calcutta. *Proc. Nat. Inst. Sc. Ind.*, **4**, pp. 229–235.

SIDDONS, L. B. (1946) ... *Anopheles stephensi* as a vector of malaria in Calcutta. *J. Mal. Inst Ind.*, **6**, pp. 367–376.

SUR, P. (1928) ... ... *Anopheles philippinensis* as a natural carrier of the malaria parasites in Bengal. *Ind. J. Med. Res.*, **16**, pp. 45–47.

SUR, S. N., and SUR, P. (1929) ... Report of the Bengal Field Malaria Research, Krishnagar Laboratory, 1926–1928. Bengal Govt. Press, Calcutta, p. 5.

TIMBERS, H. G. (1935) ... Studies on malaria in villages in Western Bengal. *Rec. Mal. Surv. Ind.*, **5**, pp. 345–370.

Indian Journal of Malariology, 2, 4, December 1948.

REPORT ON A PILOT SCHEME FOR MALARIA CONTROL IN THE BETELNUT-GROWING AREAS IN PUTHUR TALUK, SOUTH KANARA DISTRICT, MADRAS PROVINCE, 1947-48.*

BY

S. P. RAMAKRISHNAN, M.B.B.S., D.P.H.,

K. S. KRISHNAN, B.SC.,

AND

V. RAMAKRISHNA, M.A.

(*Malaria Institute of India.*)

(January 3, 1949.)

CONTENTS.

* The scheme was financed by the Indian Council of Agricultural Research.

INTRODUCTION.

THE Malaria Institute of India undertook a pilot scheme for malaria control in a betelnut-growing area in South Kanara District on behalf of the Indian Council of Agricultural Research in April 1947, with the object of determining an economical method suited to the unusual conditions and special features prevailing in this region. For this purpose a sum of Rs. 40,000 was sanctioned for one year.

A reconnaissance survey of the area was made in the first half of May to select suitable villages and in this connection the Director of Public Health, Madras, his staff in the South Kanara District, local officials, and non-officials were approached for their co-operation.

REGION SELECTED.

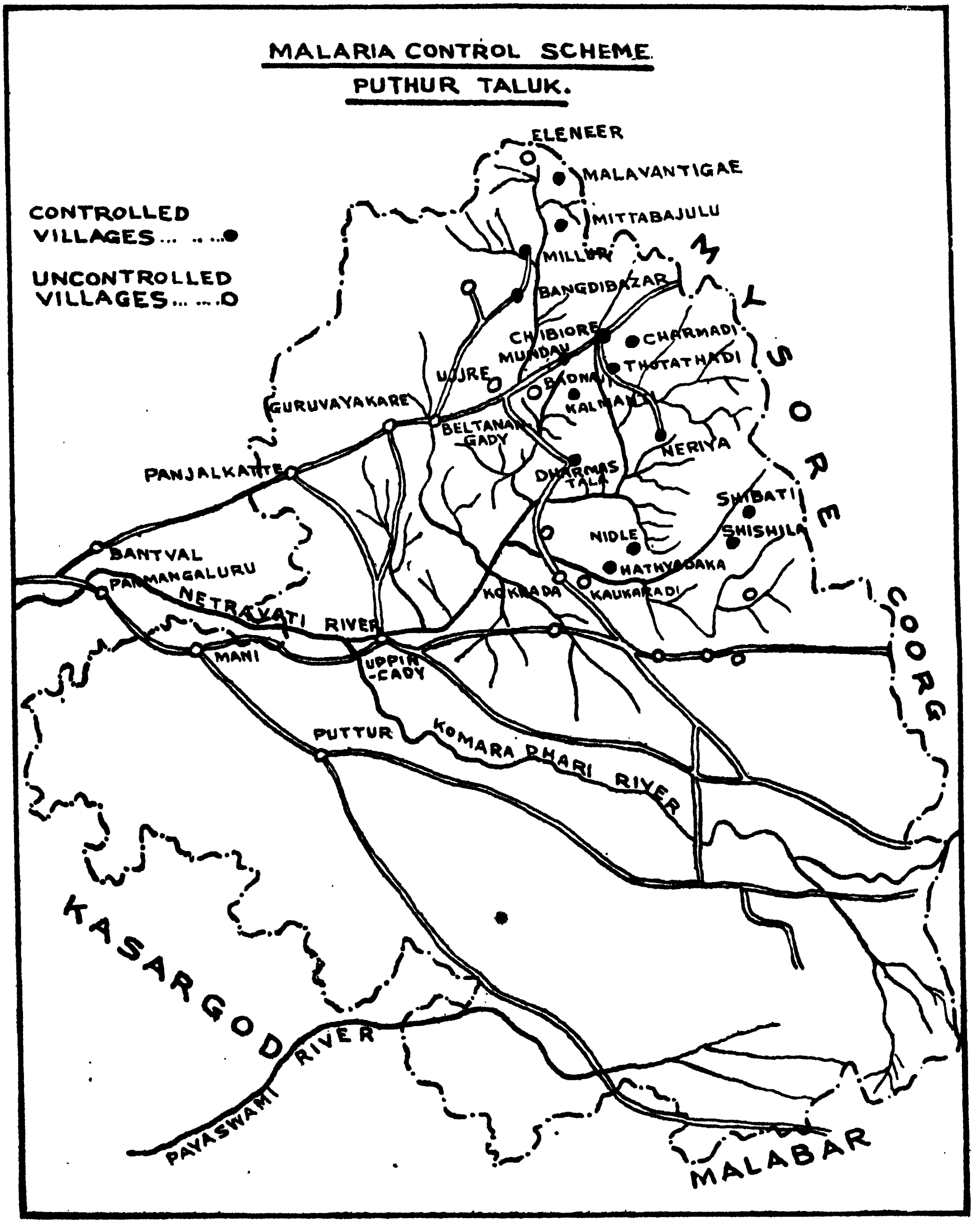
A rapid survey of the villages with betelnut cultivation in Puthur Taluk, covering approximately half the area of betelnut plantations of the entire district, was completed in June 1947, and sixteen villages, namely, Mundaje, Kalmanje, Laila, Mithabagalu, Malavantigae, Kadiruthyawara, Neriya, Nidle, Dharmasthala, Hathyadka, Sishila, Badnaje, Chibidrae, Charmady, Thotatadi and Kanyady, situated in an area of approximately 250 square miles, were selected.

TOPOGRAPHY OF THE AREA.

Puthur Taluk is roughly triangular in shape with the Western Ghats separating it from Mysore and Coorg on the east (Map). Its other boundaries are those of Karkal, Mangalore and Kasargod taluks respectively.

The soil is mainly laterite except in the foothill region where it is mixed with clay. Three main rivers, Nethravati, Kumaradhari and Payaswami, traverse from the Western Ghats towards the Arabian Sea, and most of the betelnut cultivation is confined to the upper reaches of these rivers and their tributaries called 'Holes' (Map). While the western part adjacent to the coastal region has scattered endemic foci of malaria, this disease is prevalent in hyperendemic form in the foothill zone of the Western Ghats. The terrain in the central part is

MAP.


MALARIA CONTROL SCHEME
PUTHUR TALUK.
CONTROLLED VILLAGES... .....●
UNCONTROLLED VILLAGES... ....O
ELENEER
MALAVANTIGAE
MITTABAJULU
BANGDIBAZAR
CHIBIORE
CHARMADI
THOTATHADI
UJIRE
GURUVAYAKARE
BELTANAGADY
NERIYA
PANJALKATTE
DHARMASTALA
SHIBATI
SHISHILA
NIDLE
BANTVAL
PANMANGALURU
HATHYADAKA
NETRAVATI RIVER
KOKRADA
KAUKARADI
MANI
PUTTUR
KOMARA DHARI RIVER
MYSORE
COORG
KASARGOD
PAYASWAMI RIVER
MALABAR

undulating and studded with 50 to 100 feet high hillocks. The natural drainage in this part is adequate and consequently malaria is not a serious problem.

BETELNUT PLANTATIONS.

Of the total acreage of this crop in the district (18,000 acres—revenue statistics), approximately 9,000 are in this taluk. The crop is perennial and can be classified into two types. One uncommon variety is a comparatively dry crop growing only at an elevation of about a thousand feet and the second is a wet crop confined to narrow belts on either side of streams and rivers near the foothills, except in the vicinity of the springs.

METEOROLOGICAL CONDITIONS.

This region is affected by the south-west monsoon, which usually commences in the first week of June and lasts till September. The annual rainfall is about 135 inches, the bulk of which occurs during June, July and August. In 1946, a total of 173 inches was recorded (Table I).

The average daily maximum temperature ranges from 79·0 to 97·0°F., while the minimum is between 70·0 and 78·0°F. During the dry months of the year—January, February and March—relative humidity varies from 35 to 43 per cent but from April onwards it increases reaching 85 to 90 per cent during July, August and September.

POPULATION AND HOUSING CONDITIONS.

The total population of the 16 selected villages in 250 square miles is 13,500 and is scattered, with a density of roughly 54 persons per square mile. There are no large villages as seen elsewhere in India. The landlord of a plantation owns a well-built house, around which a few labourers' huts are usually constructed. The nearest habitations to these are similar clusters in the neighbouring plantations, maybe a furlong to half a mile away from one another, and communications are by means of footpaths only. Some estates are at times completely isolated during the monsoon months. The houses are built of laterite and mortar and the huts of mud with thatched roofs. The houses may have more than one story and the upper ones are used for drying and storing betelnut and other farm produce. Cattlesheds of a closed type are built adjacent to the houses to afford protection to the cattle from wild animals.

MALARIA PROBLEMS.

The region is a naturally fertile one, capable of immense development, provided malaria can be controlled or eradicated. The Expert Committee on Malaria of the World Health Organization in their second session in June 1948 remarked (page 17 of the report) that one problem is malaria preventing the development of an area otherwise suitable for agricultural development. The following is a

quotation from the report and is applicable to this area in so far as the local relationship of agriculture and malaria is concerned : 'Thus in a naturally rich agricultural area, which already supports a farming population as efficient as health conditions permit or in a potentially rich undeveloped area readily accessible to a congested agricultural area, it may be that the removal of handicap of malaria will produce quick and spectacular development.'

Almost every year the number of deaths in this region exceeds that of births (Table II) ; 37 to 57 per cent of the total deaths are recorded as due to fevers and majority of these are no doubt due to malaria and its sequelæ.

As stated above, the betelnut-growing area is characterized by hyperendemic conditions and similar to the corresponding areas in North Kanara as described by Viswanathan and Parikh (1946) and Viswanathan and Rao (1947). *A. fluviatilis* is the sole vector with a very high infection rate of 8·7 per cent. *A. fluviatilis* is well known to favour outdoor resting places, and Mohan (1945) in his study of bionomics of this species found that largest numbers enter houses before midnight, but feed after midnight, and that during the intervals, remain indoors. They are usually not encountered in cowsheds and for these reasons *A. fluviatilis* malaria can be successfully tackled by the application of D.D.T. on the inside surfaces of houses, in spite of the accredited tendency of this species to rest outdoors.

Their larvæ are found in order of preferential breeding places, in nullahs, river edges, irrigation channels and paddy fields. As described by Viswanathan and Rao (1947), in this area also there is no part of the year intrinsically unsuitable for transmission and the only limiting factor is the non-availability of suitable breeding places during the monsoon months when all the watercourses, big and small, are frequently flushed.

The betelnut plantations along the Western Ghats in the district unlike the two different zones in North Kanara described by Viswanathan and Parikh (1946), fall into a single epidemiological zone with an identical malaria season. January to June is the period of maximum transmission ; and for these reasons malaria control measures to be effective must be carried out simultaneously in this large tract of isolated habitations.

MALARIA CONTROL MEASURES.

(*a*) *Spraying material used.*—Three applications of D.D.T. were made during the year—(1) in June-August 1947, (2) in January-February 1948, and (3) in April-May 1948. During the first round 2·5 per cent D.D.T. suspension prepared with gelatine and gum acacia (Puri, 1947) was used. The wholetime supervision of a superior field worker was necessary in the preparation of suspension which could not be entrusted to labourers. 2·5 per cent D.D.T.-M.K.E. emulsion in water was used in the subsequent applications. Undoubtedly the suspension in water is less costly than the emulsion, but the practical difficulties involved and the expert supervision required during the preparation of the former renders it less suitable than emulsion for a large-scale use in the field.

(*b*) *Spraying equipment.*—Stirrup pumps were used in the first round of spray, but due to the fact that houses in this area are scattered, it was found that a minimum team required to operate one stirrup pump consisted of 3 men. While one man worked the pump, the second applied the spray with the lance, the third man was required to manipulate the hose, in addition to carrying stores from place to place. The stirrup pumps were of indigenous manufacture and were not precision built equipment of a uniform standard. Instead of the various parts being assembled by means of screws and rivets, a great deal of solder had been used in the manufacture. The solder frequently gave way, resulting in the considerable loss of time in frequent repairs.

For the second and third applications, Ross pattern Four Oak knapsack sprayers were used and found for this part of the country, with its special features and acute shortage of labourers, more useful and economical than the stirrup pumps, as only one man is required to operate the sprayer.

(*c*) *Dosage of insecticide.*—The malaria field workers were first trained to spray water on measured surfaces, so that the speed of spraying could be regulated to deposit about 2 c.c. of the material per square foot. Tables IV, V and VI give the details of the different formulations used in the three applications.

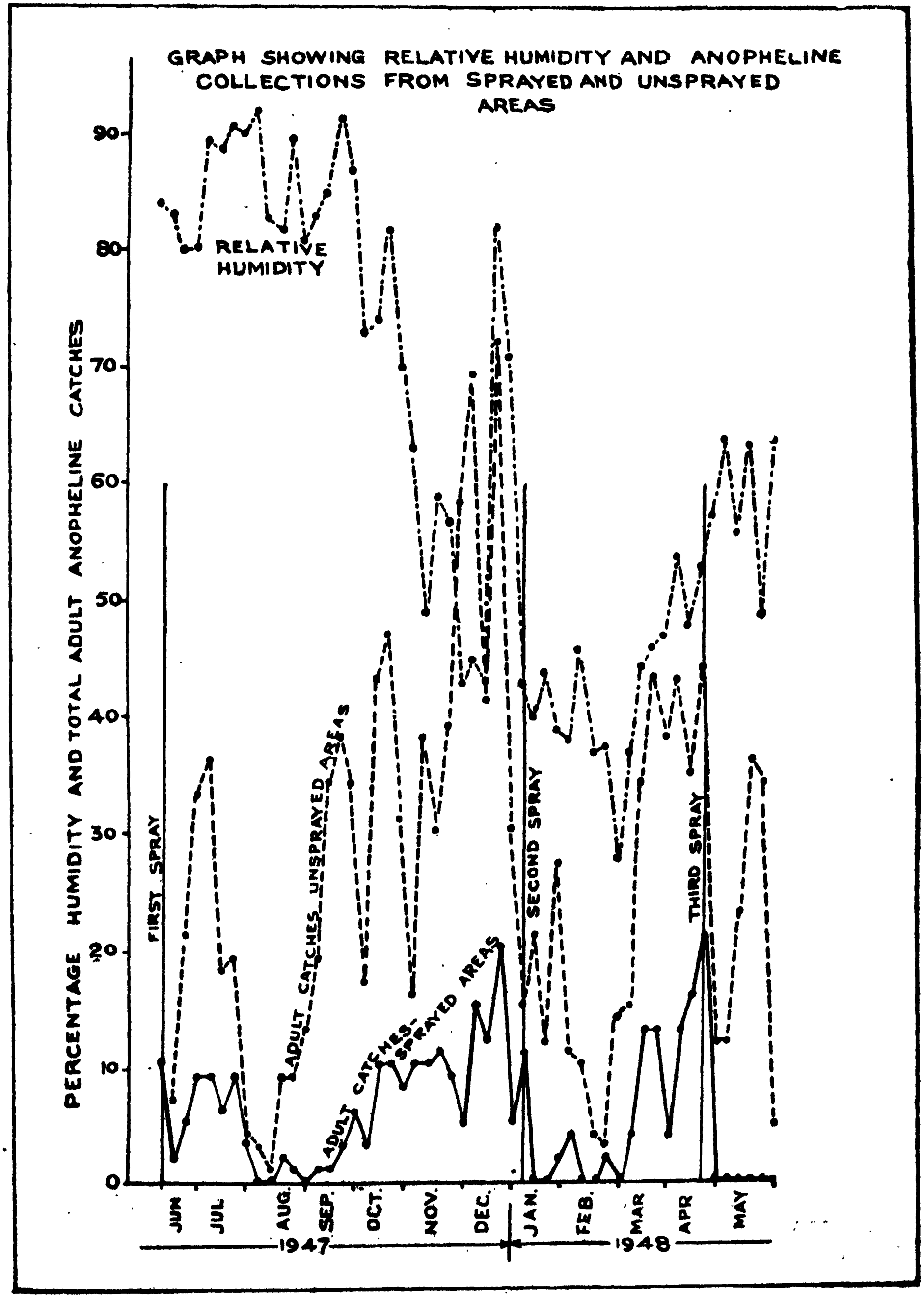
During the first round, all surfaces sprayed were accurately measured but it was found that this was a time-consuming method requiring a wholetime inspector or a superior field worker and a labourer. Consequently during the second and third rounds of spray, sample measurements as a check were found adequate. As a routine, an inspector started work with one particular spraying team at the beginning of the day and measured the surfaces sprayed, taking into account the quantity of spraying material at the start and the unsprayable residue left over. Thus the dosage of spray per square foot was frequently calculated and, if found necessary, regulated.

(*d*) *Frequency of spraying.*—As evidenced from the entomological data in the sprayed and unsprayed areas, density of the vector species was low throughout and the duration of residual effect had to be based on the density of other anophelines. The data compiled in Tables VIII, IX and X are presented in Graph 1.

In Mundaje the first spray was applied in June 1947 and the second in January 1948. An average dose of 50 mg. per square foot of 2·5 per cent D.D.T.-water suspension was applied. In all other villages same dosage of D.D.T.-M.K.E. emulsion was used during the second and third sprays. As judged from the mosquito catches, it may be said that the residual effect of June spray lasted for a period of over five months, during which period the relative humidity was constantly high.

The residual effect of the second spray in January 1948 was noticed to last till the third week of April (a period of about 3 months), but the exact period of residual effect of the third spray in April-May could not be completely determined as activities of the pilot scheme had to be terminated in June. It may be concluded that in this area the residual effect of D.D.T. spray lasts longer with

GRAPH 1.



GRAPH SHOWING RELATIVE HUMIDITY AND ANOPHELINE COLLECTIONS FROM SPRAYED AND UNSPRAYED AREAS
PERCENTAGE HUMIDITY AND TOTAL ADULT ANOPHELINE CATCHES
0
10
20
30
40
50
60
70
80
90
RELATIVE HUMIDITY
FIRST SPRAY
SECOND SPRAY
THIRD SPRAY
ADULT CATCHES UNSPRAYED AREAS
ADULT CATCHES-SPRAYED AREAS
ADULT CATCHES-SPRAYED AREAS
JUN
JUL
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR
APR
MAY
1947
1948

high relative humidity as compared with that applied at a time when humidity was constantly low. In dry areas of Northern India, applications have to be repeated at 6 weeks' intervals.

(*e*) *Structures sprayed.*—As repeated searches did not reveal any specimens of *A. fluviatilis* in the upper stories of houses used as store godowns, applications of spray were confined to the indoor surface of the inhabited rooms and cowsheds. The number of structures sprayed is indicated below :—

Number of villages.	Period of spray.	Number of structures.
13	June-Aug. 1947	2,738
12	Jan.-Feb. 1948	2,763
13	Apr.-May 1948	3,244

(*f*) *Transport.*—Motor transport was of only partial use for transporting labour, equipment and material along the few main roads to certain points nearest to a few groups of farms in this area. Often the teams had to walk miles up steep slopes to reach scattered farms with scanty population.

(*g*) *Labour.*—Local labour for odd duties was not readily available and as it is casual, labourers are imported with difficulty every year during the monsoon for spraying the betel fruits with copper sulphate solution to prevent spread of a fungus disease. During these investigations labour became available only due to the co-operation of some of the enthusiastic landlords.

The most difficult problem regarding the labour was that while the unit moved from village to village for spraying it was not possible in most cases to return to Mundaje at the end of each day's work. Board and lodging of the labourers had therefore to be arranged on each occasion they were away from headquarters, particularly in the absence of choultries or hotels as are found in towns and cities.

Another difficulty was that no employment could be given to the imported labourers during the inter-spray periods. On the contrary, had the labourers been dispensed with, the difficulty of getting them back for the subsequent applications of insecticides would have been enormous. It was possible to persuade some landlords to find them alternative employment during the slack periods. Due to the novelty of the operations such a system did work during the year of investigations but it is unlikely that it can become a regular feature.

(*h*) *Costs.*—The actual expenditure incurred between June 1947 to May 1948 directly due to the control measures is as follows :—

		Rs.	A.	P.
I.	*SALARY AND DEARNESS ALLOWANCE :			
	Malaria assistant (9 months and 7 days) ...	2,025	0	0
	Malaria inspector (9 months)	1,215	0	0
	3 superior malaria field workers (2 for 12 months and 1 for 9 months and 21 days).	1,687	8	0
	Van driver for 6 months	300	0	0
II.	TRAVELLING ALLOWANCES FOR STAFF (estimated) It is not possible to calculate separately travelling allowance payable directly due to control work.	600	0	0
III.	TRANSPORT :			
	Truck including spare parts, registration, etc. ...	11,042	8	6
IV.	PETROL, OIL AND LUBRICANTS	1,053	10	9
V.	EQUIPMENT, STIRRUP PUMPS, BUCKETS, ETC. ...	1,155	15	6
VI.	MAINTENANCE OF EQUIPMENT	77	8	0
VII.	TRANSPORT CHARGES FOR EQUIPMENT AND STORES ...	1,154	0	0
VIII.	STORES :			
	D.D.T., 1,270 lbs. @ Rs. 4 per lb.	5,080	0	0
	Gum acacia, 19½ lbs.	19	8	0
	Gelatine, 11 lbs.	44	0	0
	M.K.E., 208 gallons @ Re. 1-12 per gallon ...	364	0	0
	Lux flakes, 137 pkts.	161	12	0
IX.	STATIONERY AND POSTAGE	149	8	6
X.	MISCELLANEOUS CONTINGENT EXPENSES ...	149	2	6
	TOTAL EXPENDITURE ...	26,279	1	9

	Rs.
*SALARY :	
Malaria assistant	174/- p.m.
Malaria inspector	100/- p.m.
Superior malaria field worker ...	25/- p.m.
Van driver	35/- p.m.
Malaria field worker	35/- p.m.
DEARNESS ALLOWANCE :	
Malaria assistant	45/- p.m.
Malaria inspector	35/- p.m.
Superior malaria field worker ...	25/- p.m.
Van driver	25/- p.m.

As the Malaria Institute of India had deputed certain members of the staff during certain periods, the above total does not indicate correct expenditure figure that would have otherwise been incurred. For instance, one malaria assistant of the Malaria Institute worked in this organization before an assistant and an inspector were actually recruited in July and August 1947, respectively. The van driver was recruited in January when the transport became available. Besides, the labourers were paid only during the actual spraying periods and during

the intervals were employed locally. Normally in a scheme the labour would have to be employed at least during the entire period of 8 months in a year during which the control measures are required.

The item of expenditure of just over Rs. 11,042 for the purchase of a truck cannot strictly speaking be included in the cost of one year's control work. The normal life of a motor vehicle may be assumed to be at least 10 years and as such only one-tenth of the cost of the vehicle should be included in the first season's expenditure of the scheme. In any case, during the six months that the truck was available the total mileage run was only about 5,000 miles.

Similarly the total expenditure incurred on equipment has not been charged in the first year budget. Estimating the life of the spraying equipment to be 5 years, only one-fifth of the cost is chargeable to the first year.

Finally the rent of a building for storing material, equipment and a small laboratory has not been included as in this case accommodation was provided rent free. A reasonable estimate for the hire of suitable premises in this area would be at least Rs. 25 a month.

The following estimate of expenditure would have been incurred on control operations for the year had it not been for certain special features as mentioned above :—

		Rs.	A.	P.	Rs.	A.	P.
I.	SALARY AND DEARNESS ALLOWANCE :						
	Malaria assistant and malaria inspector for 12 months.	4,245	0	0			
	3 superior field workers for 12 months.	1,800	0	0			
	15 field workers for 8 months ...	4,200	0	0			
	Van driver for 12 months ...	600	0	0			
					10,845	0	0
II.	TRAVELLING ALLOWANCES FOR 12 MONTHS FOR ALL THE STAFF @ Rs. 50/- a month.				600	0	0
III.	TRUCK INCLUDING SPARE PARTS (1/10 of cost).				1,104	4	0
IV.	PETROL, OIL AND LUBRICANTS (sufficient for 3 applications of spray).				1,405	0	0
V.	EQUIPMENT, STIRRUP PUMPS, BUCKETS, ETC.				231	0	0
VI.	MAINTENANCE OF EQUIPMENT ...				77	8	0
VII.	TRANSPORT CHARGES FOR EQUIPMENT, STORES, ETC.				1,154	0	0
	Carried forward ...				15,416	12	0

		Rs.	A.	P.	Rs.	A.	P.
	Brought forward ...				15,416	12	0
VIII.	STORES :						
	D.D.T., 1,270 lbs.	5,080	0	0			
	Gum acacia, 19½ lbs.	19	8	0			
	Gelatine, 11 lbs.	44	0	0			
	M.K.E., 208 gallons	364	0	0			
	Lux flakes, 137 pkts.	161	12	0			
					5,669	4	0
IX.	STATIONERY AND POSTAGE ...				149	8	6
X.	MISCELLANEOUS CONTINGENT EXPENSES.				149	2	6
	TOTAL EXPENDITURE ...				21,384	11	0

Thus it will be seen that control measures in the betelnut area with a governmental organization costs approximately Rs. 21,400 per year and will afford protection to about 11,800 persons of the 13 sprayed villages at a *per capita* cost of Re. 1-13 per year.

The actual expenditure involved for each of the 3 sprays is shown in Table VII.

The last application of spray cost only Re. 0-4-4 per head and calculated on this basis 3 sprays during the year will cost roughly Re. 0-13-0 per head. The 50 per cent increase in the *per capita* cost per year of malaria control due to the overhead expenses of a governmental organization is very striking. This combined with the various difficulties of labour and communications already discussed necessitated the planning of a more suitable organization well within the economy of the community. With this end in view a co-operative method of spraying by the people themselves was tried in 4 villages, Ujjre, Sishila, Mala and Durga, and is described below :—

(*i*) *Organization.*—In view of the local difficulties of obtaining labourers, accommodation, etc., the following organization was set up :—

Malaria assistant.

Malaria inspector. — Motor transport and driver.

Superior field worker. — Superior field worker. — Superior field worker.

4 field workers. — 4 field workers. — 4 field workers.

All the three teams were moved together from village to village and in each place different sectors of the habitation were allotted to each team for spraying.

Wherever the control measures were carried out, people were enthusiastic and gave full co-operation. From villages outlying the area selected for control, people requested to be trained to do their own spraying and expressed willingness to purchase equipment and D.D.T. water soluble spray (Geigy) that was available in the market. This opened up a possibility of malaria control by a co-operative or group effort and advantage was taken of the circumstances to give the method a trial.

Four villages were selected for the trials, three of which were outside Puthur Taluk while the fourth was not far away from the controlled zone. The people of these villages had heard of the good results of D.D.T. spraying and some had experienced the same while visiting the controlled villages. All that was necessary on reaching the villages with equipment and spray material, was to seek out an influential landlord and explain to him the purpose of the visit. In a very short time he gathered the leading people of the village who in their turn produced the volunteers.

Knapsack sprayers as well as stirrup pumps were used in these trials with both men and women who came forward as volunteers. A short period of training which lasted 20 minutes in each case was utilized in explaining the parts of the equipment and demonstration in the method of use of the same. This was immediately followed by allocating the equipment to the volunteers who were first taught to spray a wall with water. At this juncture the speed of spraying was regulated with instructions on uniform coverage of the surface sprayed and the visual test of the surface being just wet and not dripping.

There was only one striking drawback in the spraying by the volunteers who in their enthusiasm showed a tendency to overdose the surfaces sprayed. All instructions that only living quarters of the houses were to be sprayed were forgotten, and the volunteers zealously sprayed the store rooms also, thus increasing the average cost of applications. This factor can be counterbalanced by issuing diluted emulsion containing 1·25 per cent D.D.T. and thus ensuring the application of adequate dosage.

Table XII gives the details of the trials on co-operative spraying.

The cost of applying indoor residual spray of 2·5 per cent D.D.T. by volunteers in four villages with a population of 1,533 was as follows :—

	Rs.	A.	P.
1. Cost of 37·9 gallons of 25 per cent D.D.T.-M.K.E. emulsion concentrate @ Rs. 11-2 per gallon.	422	12	0
2. Depreciation on equipment at the rate of 20 per cent of cost per year for 6 days.	1	6	0
TOTAL ...	424	2	0

The *per capita* cost per spray in these trials works out to approximately Re. 0-4-6 which is Re. 0-0-2 more than the cost of the third spray (Table VII).

RESULTS.

(*a*) *Effect on anopheline density.*—Mosquito catching stations were selected both in the controlled area of Mundaje and for comparison purposes in the

uncontrolled area of the same village. To begin with 3 stations, two in human dwellings and one in a cattleshed, were selected in the sprayed area and a corresponding number in the unsprayed zone. Twice a week a trained insect collector searched each catching station for approximately half an hour. The number of anophelines per half-hour catches in the sprayed and unsprayed areas are shown in Table XI. The number of *A. fluviatilis* caught was extremely small to comment upon, but it may be noted that only one specimen of *A. fluviatilis* was caught in the sprayed area after commencement of spraying as compared to 42 from unsprayed areas.

Table VIII gives the data of anophelines per catch from the sprayed area which are much less than those from the unsprayed area. Tables IX and X present the data from which figures in Table XI are compiled.

(*b*) *Effect on spleen rates and the size of the average enlarged spleen.*—Examinations of children between 2 and 10 years for enlargement of spleen, and measurement of the size of the enlarged spleens were carried out in June 1947 and again in January, April and June 1948 in a few controlled villages and one uncontrolled village, Badnaje, and the results are shown in Table XIII. In the sprayed areas, the percentage of children with enlarged spleens was reduced in all cases, but the average enlargement in the size of the spleen did not show any significant reduction. In Kalmanje, while there is a significant reduction in the spleen rate and the average size of the spleen in the children from the sprayed part of the village, there is an increase in both rate and size amongst the children in the unsprayed portion. Dharmasthala shows a systematic fall in spleen rates while in June 1948 the average size of the spleen shows an increase instead of a reduction. Again in Kanyadi which was selected for studying the effect of a single spray in April, spleen rate in June 1948 shows a reduction, while the average enlarged spleen shows an increase. The only explanation that can be thought of for the anomalous findings is that in spite of considerable effort the sample examined was not the same at every examination. In the comparison village Badnaje, there is a true reflection of what happened in nature, and both the spleen rate and the average size of the spleen showed a rise in April and June compared to those of January.

(*c*) *Effect of parasite rates in children.*—Blood smears from children in five controlled villages and from Badnaje (the comparison village) were examined in January, April and June 1948, and the data are presented in Table XIV. The reduction in parasite rates in Mundaje and Dharmasthala between June 1947 and June 1948 is noteworthy. On the other hand, the parasite rate of Badnaje which was 4·6 per cent in January 1948 increased to 19·3 per cent in June.

(*d*) *Effect on infant parasite rates.*—Infant parasite rates were determined monthly on the same group of infants in Mundaje and where possible in other villages and the data collected, in controlled and uncontrolled areas, are shown in Table XV.

The infant parasite rate in June 1947 immediately before the commencement of control operations was 3·1 per cent (1 out of 32). During January to June 1948, that is throughout the entire transmission season, the monthly infant parasite rate remained 0 per cent, and fresh transmission of malaria therefore was successfully eliminated. During the same period four out of six infants examined in Sishila in March (unsprayed up to April) had parasites, and in Mala, another uncontrolled village, the infant parasite rate was 9·1 per cent in May 1948.

Out of a total of 304 infant smears examined in both controlled and uncontrolled villages, only 8 were found positive, and the earliest age at which infection was detected in this small series was 9 months.

(*e*) *Effect on infection in mosquitoes.*—Throughout the investigation only the salivary glands of mosquitoes were examined for evidence of infection in them, and the results of dissection of a total of 579 mosquitoes are shown in Table III. Sporozoites were found only in 4 specimens of *A. fluviatilis*, all of which were caught in the uncontrolled area from March to June 1948. No evidence of infection was found in the other species dissected.

(*f*) *Dispensary data.*—Figures were collected from the solitary dispensary in the entire area at Mundaje, and Table XVI gives the average total attendance and those attending for malaria during the 4 years from 1943 to 1946 as well as the actual figures for 1947 and for 1948 up to the end of the operations. The malaria morbidity is shown as a percentage of total sickness. The monthly figures from January to July 1948 are lower than the corresponding averages for the same months of the previous five years except for the month of February 1948, when there was an epidemic of whooping cough and measles amongst the children, and presumably quite a few were recorded as malaria; blood examinations of febrile children however showed negative findings. The figures for June and July 1948 were the lowest ever recorded since 1943. Thus, even by the crude morbidity figures maintained in a rural dispensary, there is an overall reduction of malaria cases by nearly 20 per cent of the total sickness as a result of one season's control work.

(*g*) *Malaria education to the community.*—A very important lasting result was that the pilot scheme turned out to be an excellent means of educating the people in the practical control aspects of malaria and the feasibility of preventing it by methods well within the reach of every family.

In the beginning the sceptic attitude of the community at the malaria control operations was noticeable and refusals to have the houses sprayed were not uncommon. But gradually and surely the visible evidence of the benefits of spraying, reduction in the number of flies, absence of biting insects, and later a dramatic reduction in fevers, convinced the people of the possibility of freedom from the devastations of malaria.

Visits from school children and others to the improvised laboratory was a sure indication of the awakening interest. As already stated, it was not long before complaints started coming in from the distant villages not included in the investigation and the inhabitants there had to be convinced that the scheme was an experiment and as such had to be operated only in a selected area. Their next request was to train them in the spraying methods so that they themselves could take up the necessary control work with equipment and material available in the market.

Advantage was taken of their enthusiasm and with the help of the head master of the school simple arithmetical sums like calculation of percentage of deaths due to malaria, man-days lost due to this disease in betelnut plantations, and the cost of spraying were introduced, as also writing up of a topical play on malaria, the subject-matter of which was the effects and the financial loss on account of the disease, means of eradication and their cost to the community. The play was enacted on a local school day and proved most successful in its educational value.

RECOMMENDATIONS.

Organization of personnel for control.—The various aspects directly affecting the control, namely, scarcity of labour, the scattered population, lack of communications, the synchronicity of the malaria season necessitating the control operations to be carried out at the same identical time over a vast area, have already been discussed in detail. An organization considered suitable for controlling malaria in the betelnut-growing area of South Kanara District is discussed below and will require 3 years to function with full force.

FIRST YEAR.

The entire region should be divided into groups of 30 villages, each group to be in charge of a malaria inspector. It is estimated that the population in each of the inspectorates will be approximately 25,000. A malaria officer (medical) should be placed in charge of five inspectorates, each of which should be divided into 5 sub-inspectorates of 6 villages. The malaria officer should have a 15 cwt. truck and a driver at his disposal for his travelling as well as distribution of stores to the inspectorates and sub-depots. The staff and equipment for each sub-inspectorate should be as shown below :—

Superior field worker (6 villages).	Superior field worker (6 villages).	Superior field worker (6 villages).	Superior field worker (6 villages).	Superior field worker (6 villages).
Spraying team of 6 labourers.	Spraying team of 6 labourers.	Spraying team of 6 labourers.	Spraying team of 6 labourers.	Spraying team of 6 labourers.
5 knapsack sprayers. 4 buckets. 2 drums of 5 gallon capacity.	5 knapsack sprayers. 4 buckets. 2 drums of 5 gallon capacity.	5 knapsack sprayers. 4 buckets. 2 drums of 5 gallon capacity.	5 knapsack sprayers. 4 buckets. 2 drums of 5 gallon capacity.	5 knapsack sprayers. 4 buckets. 2 drums of 5 gallon capacity.

It is estimated that the scheme will cost in the first year approximately Rs. 56,000 and protect about 80,000 people.

During the operation of the pilot scheme effort should be made to educate the people in the control of malaria as described on page 260.

SECOND YEAR.

The scheme would operate as in the first year with the exception that the only paid staff will be the malaria officer, the inspectors, and a driver. The transport and the equipment will be the same as the ones used in the first year. The labour and the local supervision will be voluntary. It is estimated that during the second year the scheme would cost about half that of the first year, namely, Rs. 28,000.

Advantage should be taken during the second year to organize village health co-operative societies which will take over the functions of organizing for the future, storing material, maintaining equipment, etc.

THIRD YEAR.

The malaria officer can be withdrawn and the inspectors will take sole charge and continue the operations on a co-operative basis. It is estimated that the cost of control from the third year onwards will be about Rs. 20,000 or even less directly dependent on the cost of items like D.D.T. and M.K.E.

It is considered that greater success of a scheme like this would be achieved if the Government could arrange to supply stores like D.D.T. and M.K.E. to the co-operative units direct at cost prices.

Method of control.—It is considered that under the present circumstances, the only method of control economically feasible in these areas is that of application of residual D.D.T. on the inside surfaces of houses and cattlesheds.

Number of applications of spray.—The maximum number of sprays required in a season in this region is three, first one in January, second in April and the third in October. During the three years of experimentation it should be possible to determine whether the third spray in October is essential. This can easily be determined by withholding the spray in a few test villages and studying the results.

Dosage of spray.—It is considered that a suitable dosage of D.D.T. for this area is 50 mg. per square foot of surface sprayed. This is best achieved by using a 2·5 per cent D.D.T.-M.K.E. water emulsion or any other equivalent.

Equipment.—For conditions observed in this area, knapsack sprayers are considered the most suitable for spraying till a better type of equipment is designed.

SUMMARY.

The activities of the pilot scheme for malaria control in the betelnut farms in Puthur Taluk, South Kanara District, conducted by the Malaria Institute of India, during the year June 1947 to May 1948, are described in the report.

The malaria season is from January to June every year and *A. fluviatilis* is the carrier.

2·5 per cent D.D.T. suspension as well as D.D.T.-M.K.E. emulsion in water were tried as indoor residual spray on the surfaces of houses and cattlesheds. Approximately 50 mg. of D.D.T. were deposited per square foot and the toxic effect of the D.D.T. lasted for three months during a period when atmospheric humidity was low, and for five months during a period when the atmospheric humidity was higher.

Stirrup pumps as well as knapsack sprayers were tried for spraying, and the latter were found to be the more suitable type of equipment for use in the area.

Judged by epidemiological as well as entomological indices, malaria can be controlled in the area by the use of D.D.T. spray on indoor surfaces of houses and cowsheds. The lowest cost of spraying during the investigations was found to be Re. 0-4-4 per spray per head of the population.

It has been determined that two sprays, one in January and the second in April, are essential. A third spray in October may or may not be necessary and this can be determined after two to three years' work in the area.

The governmental organization required for malaria control operations is described. A few experiments undertaken to evolve a co-operative scheme for spraying by the villagers themselves are discussed.

ACKNOWLEDGMENT.

The authors wish to record their thanks to Mr. M. N. Bhide, President of the All-India Supari Federation, for the valuable assistance rendered by him with his intimate knowledge of the local conditions and for making buildings for office, laboratory and residence of the staff available free of rent.

REFERENCES.

MOHAN, B. N. (1945) ... *Annual report of the Malaria Institute of India*, pp. 10-14.

PURI, I. M. (1947) ... ... *Ind. J. Mal.*, **1**, 1, pp. 211-219.

RAGHAVENDRA RAO, K. (1929) *Report on malaria survey in Pattur Taluk, South Kanara District.* Supdt., Govt. Press, Madras.

VISWANATHAN, D. K., and PARIKH, R. O. (1946). *J. Mal. Inst. Ind.*, **6**, 4, pp. 383-391.

VISWANATHAN, D. K., and RAMACHANDRA RAO, T. (1947). *Ind. J. Mal.*, **1**, 4, pp. 503-542.

TABLE I.

Meteorological data.

Month.	Mean temperature, °F.		Relative humidity.	Rainfall, inches.
	Maximum.	Minimum.		
1947.				
Jun.	82·9	74·8	81·4	17·09
Jul.	79·1	73·8	89·6	60·47
Aug.	81·8	74·6	85·0	53·90
Sep.	81·5	73·4	85·9	20·36
Oct.	86·0	74·0	74·3	9·01
Nov.	88·9	70·8	53·5	0·70
Dec.	89·0	70·4	60·0	1·55
1948.				
Jan.	90·3	70·3	41·8	0·40
Feb.	92·5	72·9	35·8	0·00
Mar.	96·4	76·8	43·2	0·20
Apr.	94·6	78·1	52·7	2·26
May	92·5	77·5	58·9	2·75
Jun.	92·5	77·0	67·9	30·80

TABLE II.

Vital statistics figures for 1945 *and* 1946.

Name of village.	Population.	1945			1946		
		Births.	Deaths.	Deaths due to fever.	Births.	Deaths.	Deaths due to fever.
Badnaje ...	1,176	51	57	23	55	29	12
Kalmanje ...	992	53	30	15	29	37	10
Dharmasthala ...	1,445	28	74	32	45	62	11
Malavantigae ...	660	16	21	12	15	21	6
Mitbabagalu ...	775	20	32	24	23	34	2
Charmady ...	728	30	33	18	24	36	12
Chibidrae ...	381	13	17	12	10	12	7
Thotatadi ...	559	18	24	16	19	30	13
Neriya ...	1,053	22	35	25	18	40	22
Nidle ...	880	23	34	26	22	24	20
Hathyadka ...	1,114	36	38	18	44	31	10
Kaukarday ...	926	15	23	11	21	17	12
Kokkada ...	1,373	36	69	29	58	51	10
Nelliyadi ...	1,107	27	48	20	29	33	17
Shibaji ...	515	13	22	9	15	18	7
Sishila ...	328	19	20	15	22	23	13
Sullia ...	2,571	83	89	41	93	60	35

TABLE III.

Results of dissection of mosquitoes.

Month.	*A. culicifacies.*		*A. fluviatilis.*		*A. jeyporiensis.*		*A. varuna.*		*A. aconitus.*		SPRAYED AREA. *A. fluviatilis.*		UNSPRAYED AREA. *A. fluviatilis.*	
	Number dissected.	Gl+.	Number dissected.	Gl+.	Number dissected.	Gl+.	Number dissected.	Gl+.	Number dissected.	Gl+.	Number dissected.	Gl+.	Number dissected.	Gl+.
1947.														
Jun. ...	...	...	3	0	...	...	...	...	...	...	...	...	3	...
Sep. ...	...	...	...	...	57	0	...	...	...	...	...	...	...	...
Oct. ...	5	0	...	...	152	0	5	0	...	...	...	...	...	...
Nov. ...	1	0	...	...	15	0	12	0	...	...	...	...	...	...
Dec. ...	...	...	...	...	62	0	6	0	...	...	...	...	...	...
1948.														
Jan. ...	2	0	...	...	86	0	...	...	...	...	...	...	...	...
Feb. ...	1	0	11	0	46	0	4	0	...	...	2	0	9	0
Mar. ...	5	0	14	2	24	0	6	0	...	...	...	...	14	2
Apr. ...	7	0	14	0	1	0	16	0	1	0	2	0	12	0
May ...	4	0	2	1	...	...	2	0	...	...	...	...	2	1
Jun. ...	4	0	2	1	8	0	1	0	...	...	...	...	2	1
TOTAL ...	29	0	46	4	451	0	52	0	1	0	4	0	42	4

Only glands were dissected and examined for sporozoites. Sporozoite rate in *A. fluviatilis* = 8·7 per cent.

Gl+ = salivary glands infected.

TABLE IV.

Details of spraying—June to August 1947.

Name of village.	Total surface sprayed in sq. feet.	Date of spray.	Quantity of D.D.T. 2·5 per cent suspension used in gallons.	Dose of 2·5 per cent D.D.T. in c.c. per sq. foot of surface.	Actual number of hours involved in spraying.	Average number of pumps used per day.	Number of structures sprayed.
Mundaje ...	430,970	June 6, 7, 9, 10, 11, 12, 13, 14, 16.	224	2·5	63	3	525
Kalmanje ...	174,469	June 17, 18, 19	77	2·1	18	4.	191
Kadiruthyawara (Badnaje). ...	27,850	June 19 ...	14	2·4	6	1·5	23
Kadiruthiavara and Mithabagalu.	41,730	June 30 ...	20	2·3	7	4	172
Kadiruthiavara and Mithabagalu.	58,985	July 1 ...	30	2·4	9	4	172
Bangadi group of villages. (a) Kadiruthiavara (b) Malavantigae (c) Mithabagalu	482,948	June 19, 30; July 1, 11, 12, 13, 14, 15, 16.	197	1·95	64½	4	473
Chibidrae ...	58,868	July 20 ...	28	2·2	7	4	52

Thotatadi ...	76,590	July 21 ...	30	1·9	5½	4	55
Charmady ...	48,842	July 22 ...	18	1·7	4½	3	18
Dharmasthala ...	624,536	July 24, 25, 26, 28, 29, 30, 31; August 1, 2, 8.	324	2·4	62½	4	341
Nidle	414,072	August 3, 4, 5, 6	163	1·9	31	3·5	261
Neriya	321,441	August 11, 12, 13, 14, 15.	151	2·2	30	4	266
Hathyadka ...	313,139	August 22 to 28	162	2·4	30	3	189

Each stirrup pump was manned by a team of 3 men.
A team of 3 men and a superior field worker are permanently detailed for making D.D.T. master suspension.
No spraying could be done with effect from June 20 to June 29 for want of D.D.T.

TABLE V.

Details of spraying—January-February 1948.

Name of village.	Date of spray.	Quantity of D.D.T. 2·5 per cent suspension or emulsion used in gallons.	Dosage per sq. foot in test area in c.c.	Actual number of hours of spraying.	Number of pumps worked per day.	Number of structures sprayed.	* Population.
Mundaje ...	Dec. 28, 29, 30, 1947; Jan. 2, 3, 5 to 10 and 12 to 17.	468	2·3 to 3·3	80	3	358	1,176
Kalmanje ...	Feb. 2 ...	48	1·9	6	7	95	992
Laila	Feb. 3 ...	51	1·9	5	8	109	310
Mithabagalu ...	Feb. 4, 5 ...	112	2·5	11	8·5	263	775
Chibidrae, Charmady and Thotatadi.	Feb. 6, 7 ...	150½	2·3	14	8	317	1,568
Neriya	Feb. 9, 10 ...	154½	2·6	11	8	297	1,053

Badnaje Bazaar, Kadiruthyawara, etc.	Feb. 14 ...	103	2·5	12	5·5	238	569
Malavantigae ...	Feb. 13 ...	52	2·5	8	6	111	660
Nidle	Feb. 15, 16 ...	102½	2·4	13	9·5	265	880
Dharmasthala ...	Feb. 17, 18, 19 ...	178½	2·5	16	9	345	1,445
Hathyadka and Shibaji	Feb. 24, 25, 26 ...	264	2·5	22	9	365	1,114 515
TOTAL ...	...	1,684	...	198	81·5	2,763	11,057

* From District Health Officer.

TABLE VI.

Details of spraying in April-May 1948.

Name of village.	Date of spray.	Quantity of D.D.T. 2·5 per cent emulsion used in gallons.	Dosage in c.c. per sq. foot in test areas.	Actual number of spraying hours.	Number of pumps used per day.	NUMBER OF STRUCTURES SPRAYED.		Population.	REMARKS.
						Houses.	Cowsheds.		
Mundaje ...	April 17, 18, 19	291·5	2·8	25	8	226	114	1,176	
Ujjre	April 19 ...	55·0	2·1	3	6	39	22	175	Co-operative.
Kanyadi ...	April 20 ...	78·0	2·3	7¾	8	69	63	353	
Sishila	April 23 ...	60·0	2·5	6	6	45	33	200	Co-operative.
Kalmanje ...	April 30 ...	84·0	2·5	6½	8	77	42	992	
Laila	April 2 ...	97·0	3·0	7	10	70	55	321	
Mithabagalu and Malavantigae.	May 3 to 5 ...	219·0	2·9	24	10	251	206	775 660	
Charmady, Chibidrae and Thotatadi.	May 6 to 7 ...	188·0	2·7	13½	8	229	161	1,568	
Neriya	May 8, 10 ...	189·0	2·8	11¼	8	157	130	1,053	
Kadiruthyawara Group.	May 11 ...	136·0	2·8	8½	8	132	115	569	
Dharmasthala ...	May 12 to 14 ...	253·0	2·8	14	7	234	133	1,445	
Shibaji and Hathyadka	May 16 to 18 ...	300·0	2·9	19½	9	223	131	1,629	
Nidle	May 18 to 19 ...	176·0	3·0	11	9	159	108	880	
GRAND TOTAL ...		2,126·5	...	157½	...	1,931	1,313	11,796	

TABLE VII.

Cost of the three sprays.

—	1st application of spray (90 days).	2nd application of spray (36 days).	3rd application of spray (23 days).
	Rs. A. P.	Rs. A. P.	Rs. A. P.
Cost of D.D.T. suspension or emulsion used	1,460 14 0	2,080 6 0	2,369 10 0
Labour wages	1,631 10 0	420 0 0	241 8 0
Pay of inspector	390 0 0	162 0 0	99 11 0
Pay of malaria assistant	749 10 0	226 4 0	167 10 0
Pay of van driver	*Nil*	72 0 0	46 0 0
Pay of 3 superior field workers ...	*490 12 0	*180 0 0	*76 6 0
Cost of petrol	*Nil*	100 0 0	100 0 0
Depreciation cost on equipment ...	18 12 0	12 0 0	8 0 0
Contingencies (estimated)	150 0 0	50 0 0	50 0 0
Total cost	4,891 10 0	3,302 10 0	3,158 13 0
Population protected	10,230	11,057	11,796
Approximate *per capita* cost per spray ...	0 8 0	0 5 0	0 4 4

*Only 2 superior field workers were employed.

TABLE VIII.

Adult collections—all catching stations—Mundaje—unsprayed area.

Month.	*A. annularis.*	*A. barbirostris.*	*A. culicifacies.*	*A. fluviatilis.*	*A. hyrcanus.*	*A. jamesi.*	*A. jeyporiensis.*	*A. pallidus.*	*A. subpictus.*	*A. tessellatus.*	*A. vagus.*	*A. varuna.*	Per catch.
	M. F.	M. F.	M. F.	M. F.	M. F.	M. F.	M. F.	M. F.	M. F.	M. F.	M. F.	M. F.	M. F.
1947.													
Jun. ...	...	...	3 6	0 1	...	...	0 1	...	6 5	...	9 34	2 11	3 71
Jul. ...	...	...	0 1	...	...	...	0 12	...	3 2	...	5 39	...	3 44
Aug. ...	...	...	...	...	...	...	1 27	...	1 1	...	1 3	...	1 13
Sep. ...	...	...	0 1	...	0 1	...	9 116	...	0 1	...	0 1	...	2 53
Oct. ...	...	...	0 3	...	0 20	0 2	8 95	...	0 9	...	0 9	0 2	3 08

Nov.	...	...	0 3	0 3	...	1 19	...	0 13	0 1	2 29	0 3	20 64	0 5	3 48
Dec.	...	...	...	0 1	...	0 8	...	6 28	...	0 19	...	56 103	...	4 09
1948.														
Jan.	...	0 2	...	...	1 1	...	...	1 37	...	0 23	...	0 14	...	2 16
Feb.	...	...	...	...	...	...	...	2 11	...	0 6	...	0 4	0 8	1 47
Mar.	...	...	0 3	...	...	...	0 1	0 5	...	0 34	...	3 109	0 1	5 80
Apr.	...	...	0 1	...	0 3	...	...	...	...	1 57	...	4 53	1 4	4 60
May	...	...	0 5	...	0 1	...	0 1	0 2	...	0 63	...	0 25	0 1	4 70

M = Male. F = Female.

TABLE IX.

Adult collection from routine catching stations—human dwellings.

Month.	SPRAYED AREA.								UNSPRAYED AREA.							
	ALL ANOPHELINES.				*A. fluviatilis.*				ALL ANOPHELINES.				*A. fluviatilis.*			
	M.	F.	Total.	Total per catch.	M.	F.	Total.	Total per catch.	M.	F.	Total.	Total per catch.	M.	F.	Total.	Total per catch.
1947.																
Jun. ...	2	14	16	1·1	0	2	2	...	20	52	72	5·1	0	1	1	...
Jul. ...	1	14	15	1·1	0	0	0	...	5	41	46	3·8	0	0	0	...
Aug. ...	0	3	3	0·2	0	0	0	...	3	21	24	1·2	0	0	0	...
Sep. ...	3	3	6	0·2	0	0	0	...	1	30	31	0·9	0	0	0	...
Oct. ...	0	4	4	0·1	0	0	0	...	1	10	11	0·3	0	0	0	...
Nov. ...	2	12	14	0·4	0	0	0	...	13	64	77	2·4	0	0	0	...
Dec. ...	4	41	45	1·3	0	0	0	...	44	98	142	4·2	0	0	0	...
1948.																
Jan. ...	1	4	5	0·2	0	0	0	...	1	51	52	2·0	1	1	2	...
Feb. ...	0	2	2	0·1	0	0	0	...	1	13	14	1·0	0	0	0	...
Mar. ...	0	39	39	2·17	0	0	0	...	1	123	124	6·88	0	0	0	...
Apr. ...	1	42	43	2·38	0	0	0	...	5	87	92	5·11	0	3	3	...
May ...	0	0	0	0·00	0	0	0	...	0	66	66	4·76	0	1	1	...
TOTAL ...	14	178	192	...	0	2	2	...	95	656	751	...	1	6	7	...

M = Male. F = Female.

TABLE X.

Adult collection from routine catching stations—cattlesheds.

Month.	SPRAYED AREA.								UNSPRAYED AREA.							
	ALL ANOPHELINES.				*A. fluviatilis.*				ALL ANOPHELINES.				*A. fluviatilis.*			
	M.	F.	Total.	Total per catch.	M.	F.	Total.	Total per catch.	M.	F.	Total.	Total per catch.	M.	F.	Total.	Total per catch.
1947.																
Jun. ...	3	7	10	1·4	0	0	0	...	0	6	6	0·9	0	0	0	...
Jul. ...	1	11	12	1·4	0	0	0	...	3	13	16	2·7	0	0	0	...
Aug. ...	0	0	0	...	0	0	0	...	0	10	10	1·0	0	0	0	...
Sep. ...	1	4	5	0·3	0	0	0	...	8	90	98	5·8	0	0	0	...
Oct. ...	0	40	40	2·1	0	0	0	...	7	130	137	8·6	0	0	0	...
Nov. ...	0	23	23	1·4	0	0	0	...	2	78	80	5·5	0	0	0	...
Dec. ...	4	16	20	1·2	0	0	0	...	19	61	80	4·4	0	0	0	...
1948.																
Jan. ...	0	1	1	0·1	0	0	0	...	1	25	26	2·3	0	0	0	...
Feb. ...	0	0	0	...	0	0	0	...	1	16	17	2·4	0	0	0	...
Mar. ...	0	3	3	0·3	0	0	0	...	2	29	31	3·4	0	0	0	...
Apr. ...	0	0	0	0	0	0	0	...	1	31	32	3·5	0	0	0	...
May ...	0	2	2	0·3	0	0	0	...	0	33	33	4·7	0	0	0	...
TOTAL ...	9	107	116	...	...	...	...	...	44	522	566	...	...	...	...	...

M = Male. F = Female.

TABLE XI.

Comparison of anopheline catches from sprayed and unsprayed zones—Mundaje (all catches reduced to per catch of half an hour).

Month.	DAY CATCHES PER CATCH.					
	HUMAN DWELLINGS.		CATTLESHEDS.		HUMAN DWELLINGS AND CATTLESHEDS COMBINED.	
	Sprayed.	Unsprayed.	Sprayed.	Unsprayed.	Sprayed.	Unsprayed.
1947.						
Jun. ...	1·14	5·14	1·42	0·85	1·23	3·71
Jul. ...	1·07	3·83	1·40	2·66	1·28	3·44
Aug. ...	0·16	1·20	0·00	1·00	0·11	1·13
Sep. ...	0·17	0·91	0·29	5·76	0·22	2·53
Oct. ...	0·11	0·34	2·05	8·56	0·76	3·08
Nov. ...	0·43	2·40	1·43	5·50	0·77	3·48
Dec. ...	1·30	4·19	1·17	4·44	1·20	4·09
1948.						
Jan. ...	0·20	2·00	0·07	2·25	0·16	2·16
Feb. ...	0·14	1·00	0·00	2·43	0·09	1·47
Mar. ...	2·17	6·88	0·33	3·44	1·60	5·80
Apr. ...	2·38	5·11	0·00	3·55	1·60	4·60
May ...	0·00	4·76	0·25	4·71	0·08	4·70

TABLE XII.

Data of experiment on malaria control by the co-operative method.

Date.	Name of village.	Number of men trained by the unit in the village.	Number of sprayers used.	Time taken for actual spraying (hours).	Number of houses sprayed.	Number of cowsheds sprayed.	Total structures sprayed.	Emulsion used (gallons).	Population protected.
1948.									
Apr. 19	Ujjre ...	6	6	3	39	22	61	55	175
23	Sishila ...	6	6	6	45	33	78	60	200
May 28	Mala ...	8	8	7·25	93	59	152	126	450
29, 30	Durga ...	Eight labourers were trained in the first instance but they did not spray continuously throughout the day. Each house supplied one or two women for spraying. In the end every house had a man trained in spraying. One woman sprayed her own house and a neighbouring one too.	8	8	*141	81	222	138	708
			TOTAL ...	24·25	318	195	513	379	1,533

* A few houses, about 18, had to be sprayed by us as most of the inmates in the houses were down with malaria. 8 out of 10 in a house were down with fever. So no labour could be arranged by them at that moment.

TABLE XIII.

Comparative spleen rates of a few sprayed and unsprayed villages.

Name of village.	Jun.-Jul. 1947.				Jan.-Feb. 1948.				Apr. 1948.				Jun. 1948.				Remarks.
	Number of children examined.	Number with enlarged spleen.	Spleen rate, per cent.	Average enlarged spleen.	Number of children examined.	Number with enlarged spleen.	Spleen rate, per cent.	Average enlarged spleen.	Number of children examined.	Number with enlarged spleen.	Spleen rate, per cent.	Average enlarged spleen.	Number of children examined.	Number with enlarged spleen.	Spleen rate, per cent.	Average enlarged spleen.	
Mundaje ...	83	28	33·7	9·7	72	17	23·6	13·4	53	11	20·7	10·4	53	6	11·3	10·8	
Kalmanje ...	66	31	47·0	9·0	19	13	68·4	9·3	8	8	100	11·1	12	9	75	7·8	Unsprayed zone.
Kalmanje ...	...	...	...	...	...	...	...	...	7	3	43	11·3	8	2	25	10·0	Sprayed zone.
Dharmasthala ...	33	23	70·0	6·0	31	20	64·0	4·7	32	18	55·5	8·5	19	10	52·6	6·8	
Kanyadi ...	...	...	...	...	17	14	82·3	6·1	24	18	75·0	8·8	20	11	55·0	4·6	Sprayed in April only.
Badanaje ...	...	...	...	...	47	30	63·0	9·1	54	38	70·3	9·1	29	22	76·0	6·1	Comparison village where no control operations were undertaken.

TABLE XIV.

Comparative parasite rates of sprayed and unsprayed villages.

Name of village.	Jun.-Jul. 1947.			Jan.-Feb. 1948.			Apr. 1948.			Jun. 1948.			Remarks.
	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	
Mundaje ...	68	16	23·5	68	0	6	54	2	3·7	53	6	11·3	
Kalmanje ...	23	4	17·4	24	1	4·1	17*	3*	17·7*	Records lost			* Of the 17 blood smears 9 were from the unsprayed area with 2 positive and 8 were from the sprayed area with 1 positive.
Dharmasthala ...	...	...	...	40	2	5	44	1	2·3	46	1	2·1	
Badnaje ...	...	...	...	43	2	4·6	55	2	3·6	36	6	19·3	This is a comparison village where no method of malaria control was undertaken.

TABLE XV.

Infant parasite rates—unsprayed zone.

Period of examination.	MUNDAJE.			KALMANJE.			SHIBAJI.			HATHYADKA.			MALAVANTIGAE.			LAILA.		
	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.
1947.																		
Jun. ...	32	1	3·1	4	0	0	...	...	...	...	...	...	...	...	...	...	...	...
1948.																		
Jan. ...	18	0	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Feb. ...	18	0	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mar. ...	17	0	0	...	...	...	9	0	0	22	1	4·5	...	...	...	...	...	...
Apr. ...	20	0	0	5	0	0	...	...	...	19	0	0	12	0	0	4	0	0
May ...	21	0	0	...	...	...	7	0	0	14	0	0	13	1	7·7	...	...	...
Jun. ...	14	0	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
TOTAL ...	140	1	...	9	0	0	16	...	...	55	1	...	25	1	...	4	0	0

Mundaje—June 1947 ... = Quartan.
Hathyadka—March 1948 ... = Malignant tertian (crescents).
Malavantigae—May 1948 ... = Malignant tertian (crescents).

Total number of smears examined from sprayed areas ... ... = 280
Number with malaria parasites ... = 3
Infant parasite rate ... ... = 1·4 per cent.

TABLE XV—*concld.*

Period of examination.	Chibidrae.			Neriya.			Dharmasthala.			Sishila.			Mala.			Remarks.
	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	Number of smears examined.	Number with malaria parasites.	Parasite rate, per cent.	
1947.																
Jun. ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
1948.																
Jan. ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Feb. ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Mar. ...	...	...	...	...	...	...	...	...	...	6*	4*	66·6	...	...	...	* Sprayed in April 1948.
Apr. ...	...	...	...	...	...	...	...	...	...	7	0	0	...	...	...	
May ...	10	0	0	4	0	0	17	0	0	...	...	...	11	1	9·1	
Jun. ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
TOTAL ...	10	0	0	4	0	0	17	0	0	13	4	...	11	1	...	

Number of smears examined from unsprayed areas ... ... = 24
Number with malaria parasites ... ... = 5
Infant parasite rate ... ... = 20·8 per cent.

		Malignant tertian.	Malignant tertian and benign tertian.	Quartan.
Sishila—March 1948	...	3	...	...
Mala—May 1948	...	...	1	1

TABLE XVI.

Average number of cases at Mundaje dispensary, 1943 *to* 1946, *and total cases during* 1947 *and* 1948.

Month.	1943–46 Average for a year.			1947			1948		
	Total	Malaria.	Per cent.	Total.	Malaria.	Per cent.	Total.	Malaria.	Per cent.
Jan. ...	549	251	46	460	165	36	382	133	35
Feb. ...	512	211	41	448	182	41	366	153	42
Mar. ...	519	279	54	508	246	48	409	106	26
Apr. ...	520	247	48	532	260	49	367	118	32
May ...	585	288	49	593	310	52	349	123	35
Jun. ...	610	337	55	556	269	48	400	149	37
Jul. ...	609	323	53	520	283	54	396	130	33
Aug. ...	447	186	42	485	209	43	...	...	...
Sep. ...	344	114	33	350	147	41	...	...	...
Oct. ...	345	100	29	298	65	22	...	...	...
Nov. ...	415	135	33	297	80	27	...	...	...
Dec. ...	316	153	48	527	189	36	...	...	...

Indian Journal of Malariology, 2, 4, December 1948.

A SIMPLE MEDIUM FOR MOUNTING MOSQUITO LARVÆ.

BY

M. L. BHATIA, M.SC., Ph.D. (Cantab.)
(*Entomologist, Malaria Institute of India.*)

[January 17, 1949.]

THE classical method of making permanent preparations of larvæ of mosquitoes and other insects in canada balsam has universally been followed. The process is no doubt satisfactory but far from fool-proof. It entails a lengthy process for complete dehydration of the specimen by passing it through varying strengths of alcohol, and clearing it in xylol. Unless great care is taken, various long hairs, which serve as important diagnostic characteristics for the identification of the specimens, are often lost during the prolonged treatment and frequent changes of solutions. Further, specimens often become brittle in xylol. Considerable difficulties in making satisfactory mounts of larvæ have been experienced by various workers in the tropics particularly where humidity is high and alcohol readily absorbs moisture from the atmosphere. With the chloral gum mounting medium, the preparations can be made rapidly but it takes a long time before it is suitably dry for proper handling. They have to be sealed with cement round the edges, and if the medium is thin, the cement works its way in, but if it is too viscous, it often crystallizes after some time.

'Euparal', a proprietary preparation, is also widely used and gives reasonably good results but is expensive and not always readily available.

Wanamaker (1944), after giving the disadvantages of canada balsam and chloral gum as mounting media, described an 'improved' method in which he mounts the specimens in a medium composed of creosote and canada balsam previously heated slowly to drive off almost all the xylene. This medium gives good results but, according to Wanamaker, the slide has to be dried 'for 10 to 12 days preferably in an incubator' before it is ready for use. A number of specimens mounted in this medium are apt to get distorted and shrunk, and the head often does not clear properly. These difficulties can however be overcome by piercing the larvæ in one or two places when they are in absolute alcohol.

While dealing with the malaria classes conducted at the Malaria Institute of India, the necessity of evolving an easy and rapid method of making permanent mounts of mosquito larvæ has been felt for some considerable time, and as a result

of a series of trials a simple medium has now been evolved from indigenous material readily available in all parts of India.

The medium can be easily prepared by dissolving at room temperature 50 grammes of rosin (crystallined pine rosin) in 75 c.c. of eucalyptus oil (oleum eucalypti) in a stoppered bottle. It takes about 48 hours to dissolve the rosin completely but this period can be reduced to about 2 hours by placing the container in an automatic shaker. The solution should be allowed to stand for a few hours and then decanted, after which it will be ready for use.

For making permanent mounts of mosquito larvæ, the following procedure has been found suitable :—

(1) The larvæ may be killed in hot water and put into 90 to 95 per cent alcohol or they may be killed in alcohol by putting them directly into it.

(2) Change the alcohol or transfer the specimens to fresh alcohol which may be absolute or 95 per cent. Keep specimens in it for about 15 to 20 minutes. It is preferable to prick the larvæ in the thoracic region while they are in alcohol.

(3) Pick up one larva at a time and place it in the centre of a slide, remove any excess of alcohol with a piece of blotting paper and then place a few drops of the medium on it. After the larva has been properly arranged in the desired position with the help of a needle, place a coverslip over it.

The specimen becomes transparent in about half an hour. The refractive index of this mounting medium (1·497) is comparatively lower than that of canada balsam (1·524) with the result that even the very fine more or less colourless structures like the retractile thoracic notched appendages of the anopheline larvæ, mounted laterally, are clearly visible. This medium acts as a clearing as well as a mounting agent which sets hard by itself within 2 to 3 days, without the slides with the mounts being placed in an incubator. It is not necessary to seal the edges of the mounts with any cement. The medium has been found to be equally useful for unstained as well as stained objects and the larvæ need not be completely dehydrated before they are mounted.

This medium has been found useful for other insects such as fleas, ticks, lice, etc. Its consistency can be varied by adding more eucalyptus oil but it is advisable not to increase the percentage of rosin in the solution as the latter is apt to crystallize if the slide is heated for quick drying.

REFERENCE.

WANAMAKER, J. F. (1944) ... *Amer. J. Trop. Med.*, **24**, p. 385.

Indian Journal of Malariology, 2, 4, December 1948.

A SHORT ACCOUNT OF THE MALARIA PROBLEM IN MYSORE STATE.

BY

B. ANANTHASWAMI RAO, B.SC., M.B., B.S., M.P.H.
(*Superintendent, Bureau of Malariology, Department of Public Health, Mysore State.*)

[February 5, 1949.]

MALARIA is the most important health problem in the Mysore State involving practically six out of the nine districts with a population of about 76·5 lakhs. The State is divided into Malnad or hilly area along the western border and Maidan or gently rolling country forming the rest of the State. Four of the nine districts are in the Malnad area with a population of 2,552,814 and the remainder five are situated in the Maidan with a population of 5,097,186. Of the former, about 7 lakhs suffer annually from malaria, while in the irrigated tracts in the Maidan districts, about 4 lakhs get affected with this disease. It has been estimated that every year directly or indirectly deaths due to this disease total 40,000, representing about 36 per cent of the total deaths. It may be assumed that for each death at least one hundred persons suffer from attacks and get handicapped due to its after-effects.

The first systematic study of malaria dates back to 1927, when Dr. W. C. Sweet made a rapid spleen survey of the entire State. Earlier to this, a survey of Bangalore had been made by Dr. R. Subba Rao, as also a survey of isolated areas like Sivasamudram and Seringapatam by Dr. M. Srinivasa Rao.

As a result of the survey in 1927, it became possible to classify on broad lines the malaria problem and in his report to the Mysore Government, Dr. W. C. Sweet has stated as follows :—

'Kolar District is a non-endemic area for malaria and has no important endemic foci, unless it is later found to be subject to epidemic malaria, it may be excluded from areas needing attention.

'Bangalore and Tumkur districts have a few endemic foci, but are in the main free of serious malaria. These problems are ones of definitely localized areas of infection.

'Chitaldrug District contains many endemic areas of light intensity and at least one heavy endemic area. Its malaria problem is more widespread than is the one in the previously mentioned districts and forms the connecting link between the light areas and the heavy ones. The remaining four districts have very few non-endemic areas. The endemicity is high to the south in Mysore district and increases to the north-west in the Kadur and Shimoga districts. From all figures available, Kadur District seems the most heavily infected.'

Based on these observations three study stations were established during the period 1928-29 at Nagenahalli, near Mysore, Mudigere in Kadur and Hiriyur in Chitaldrug District. Detailed epidemiological investigations were carried out during the first year and relevant data in regard to the quantity and seasons of prevalence of malaria, the prevailing species of parasites and the local anopheline species with reference to their seasonal incidence, habits of breeding and their relation to local malaria were collected. The studies were also directed towards the elucidation of the seasons of active transmission of malaria (Sweet and Rao, 1933).

It was established that in these areas there were twenty-three anopheline species all of which were found in the Malnad districts; but in the Maidan area the number of species found were distinctly less, varying from 11 to 16. Of these twenty-three, only 3 species, viz. (1) *A. fluviatilis*, (2) *A. culicifacies* and (3) *A. stephensi* were definitely responsible for malaria transmission. They are encountered in rural and urban areas of the Maidan districts, while *A. fluviatilis* is also found breeding in running water channels in the foothill and irrigated areas.

The active transmission season differed considerably from area to area and even within each area it was subject to variations. This period of natural transmission of malaria ranges from 3 to 8 months, starting from about October to June in the Malnad and almost throughout the year in the Maidan, October to April being more favourable than other months.

After the preliminary studies, experiments were conducted in these stations from 1930 to 1935, in regard to the methods of control, effective range of the control operations and flight habits of the local anopheline carriers. As a result, it was suggested that the average flight range of the local anopheline carriers was half a mile and a control of two furlongs around habitations gave a reasonable protection. The chief method employed was destroying the anopheline larvæ to minimize the mosquito output and it was demonstrated that malaria could be successfully controlled by this method.

The problem in the first instance could be broadly classified from an epidemiological point of view into (*a*) urban and (*b*) rural. The rural malaria could further be classified into (1) malaria of the foothills in the Malnad, (2) malaria associated with irrigation, and (3) epidemic malaria.

(*a*) *Urban malaria* is encountered in the cities, chiefly Mysore and Bangalore, with *A. stephensi* type form as the chief vector and *A. culicifacies* and *A. fluviatilis* playing a minor rôle in the peripheral areas.

(*b*) *Rural malaria.*—(1) *Foothill malaria* is associated with high rainfall, sharp ridges and valleys, clothed with dense vegetation and perennial or seasonally

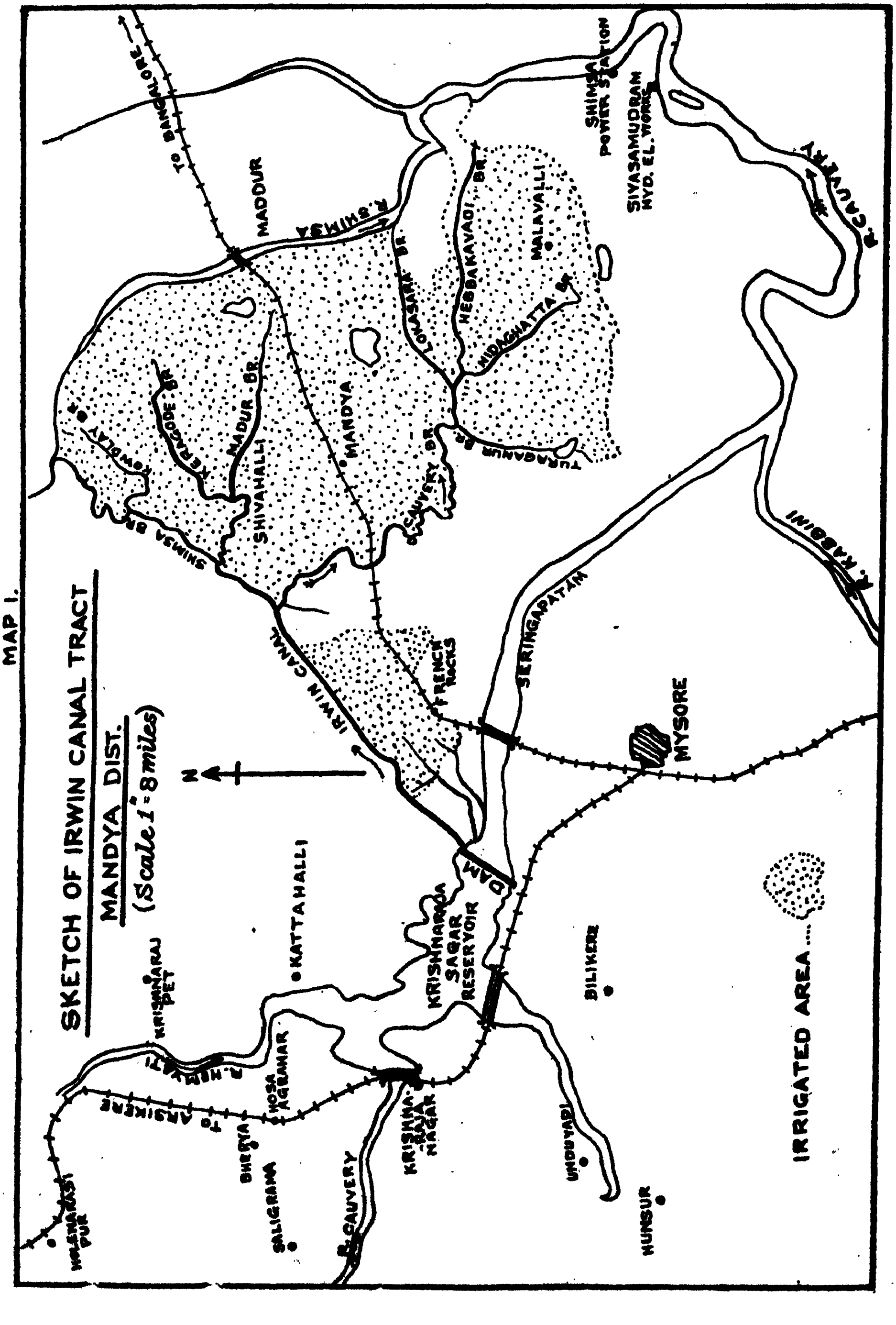
flowing streams. *A. fluviatilis*, a stream breeder, is the sole vector in this area and the season of transmission ranges from 3 to 8 months. These conclusions were drawn mainly on the basis of studies in one station at Mudigere, but the area included under Malnad being so extensive and varied in environmental and climatological conditions, further intensive studies are required.

The Malnad districts of Kadur, Shimoga, parts of Hassan and Mysore have been progressively depopulated and attempts for the prevention of conditions favouring such depopulation were started over three decades ago. But the problem is complicated, in that the population is scattered and villagers do not live in compact villages as they do in the Maidan. Quite often, one has to traverse 10 to 15 miles to visit about a dozen or more houses, which form a revenue village. Further, communications are very poor and often absent, leaving large sections of population completely isolated for 4 to 6 months during the monsoon season. Malaria is one of the chief health problems and in association with hookworm is largely responsible for the continuous depopulation, where otherwise the nature is bountiful and the whole area is considered as the granary of the State and properly tackled awaits considerable economic exploitation.

(2) *Irrigation malaria* is associated with the irrigated tracts in the Maidan and semi-Malnad areas. It has a direct relation to the extent of area under irrigation and its close proximity to the villages, and is prevalent in varying degrees of endemicity, depending on whether irrigation is seasonal or perennial. The season of transmission is practically throughout the year with varying intensities in different seasons and the two vectors are *A. culicifacies* and *A. fluviatilis*.

Malaria has followed the development of each irrigation project in the State, the earliest dating back some centuries in the Cauvery and Hemavati basins. Large tracts of land with only seasonal irrigation are hyperendemic for malaria in Mysore and Mandya districts. In 1928, when systematic investigations were started, the people in these tracts had got so used to this condition, that they did not consider it anything abnormal. More recently each new project has brought malaria with it into areas where it was practically unknown before. To cite some instances, the Vanivilas Sagar Project in Hiriyur, the Boran Kanave Project in Tumkur District, and in the last decade, the Irwin Canal Project, the Marconahalli Project and the Kanva and Byramangala Projects, in the Mandya; Tumkur and Bangalore districts, are some of the projects.

The Irwin Canal area, before the advent of the canals, was dry and one of the most healthy areas. That malaria was going to be a complicating factor was envisaged by the designers of the project, and was again stressed by the author even just before the canals were put into service in 1932. But the warning was unheeded and the essential provisions for drainage and dry belts around villages were left out. This resulted in a serious problem developing almost within a year of starting irrigation, involving a population of nearly 2 lakhs in about 300 villages. There was an appalling loss of life and the situation became so alarming by 1935 that serious attention had to be paid to this area. But it was only in 1939 that attempts were made to grapple with the problem by setting up a special organization. A full-time committee of officers from the health, engineering and


MAP I.
SKETCH OF IRWIN CANAL TRACT
MANDYA DIST.
(Scale 1" = 8 miles)
N
TO BANGALORE
MADDUR
R. SHIMSA
SHIMSA POWER STATION
SIVASAMUDRAM HYD. EL. WORKS
R. CAUVERY
MALAVALLI
HEBBAKAVADI BR.
LOKASARA BR.
MIDAGHATTA BR.
TURAGANUR BR.
CAUVERY BR.
MANDYA
MADUR BR.
SHIVAHALLI
KERAGODE BR.
HOWDLAY BR.
SHIMSA BR.
IRWIN CANAL
FRENCH ROCKS
SERINGAPATAM
R. KABBINI
MYSORE
DAM
KRISHNARAJA SAGAR RESERVOIR
KATTAHALLI
KRISHNARAJ PET
BILIKERE
R. HEMAVATI
HOSA AGRAHAR
TO ARSIKERE
KRISHNA RAJA NAGAR
CHETTYA
SALIGRAMA
R. CAUVERY
UDDUVADI
HUNSUR
IRRIGATED AREA

revenue departments was appointed to visit all affected villages and to investigate and suggest remedial measures. Based on the recommendations of this committee, permanent and recurrent antimalaria works are now in progress.

(3) *Epidemic malaria.*—This is characterized by sudden outbreaks of malaria over wide areas which have normally only a few scattered foci of low endemicity. This occurs under special conditions which favour a large output of the carrier species of anophelines in areas which normally are very dry. Such conditions follow years of unseasonal and heavy rainfall, and are peculiar to the dry districts of Kolar, Tumkur and Chitaldrug. Conditions in these areas return to normal a few years after an epidemic.

EXISTING ORGANIZATION FOR INVESTIGATION AND CONTROL.

The organization consists of two parts, one central and the other at the periphery. The central organization consists of one Superintendent, Bureau of Malariology; one Antimalaria Officer (status of a Sub-Assistant Surgeon); one Assistant to the Superintendent, Bureau of Malariology, sanctioned temporarily for one year (status of a Sub-Assistant Surgeon); and one Entomologist with three Health Inspectors and one Laboratory Attendant. This organization at the centre is responsible for all the investigations and direction of control measures in the malarious areas.

At the periphery, all malaria control work is based on health units with extra staff provided for this special work. Malaria control work is now in progress in 1,579 villages in health unit areas in 8 districts. The present budget for this work is Rs. 7,21,000 excluding the urban areas of Bangalore and Mysore cities. A statement giving the number of primary and secondary centres, number of villages served, population and the sanctioned budget is given in Appendix I.

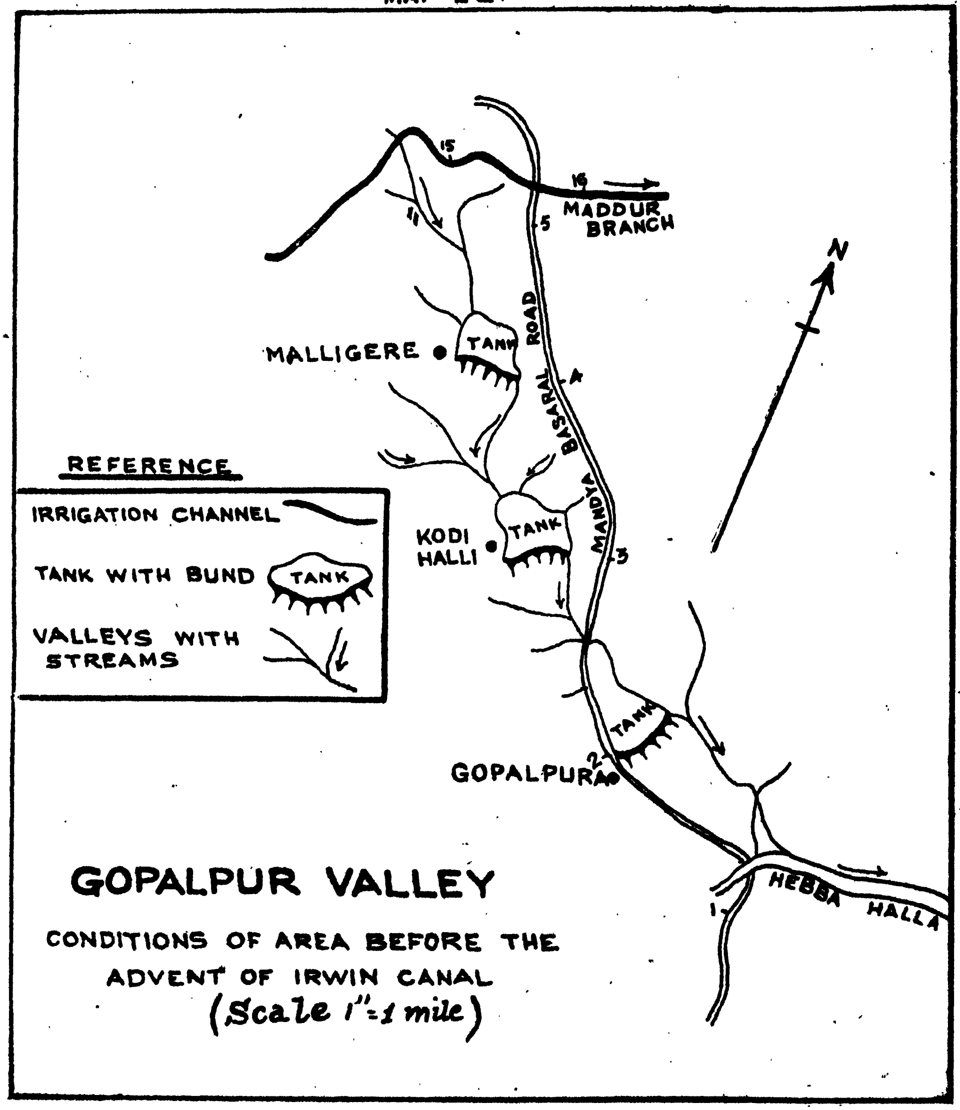
CONTROL MEASURES.

These include recurrent measures directed against the different stages of life-cycle of the mosquito, either the larval or the adult stages, and have to be kept up as long as control is desired. As against these, there are the permanent measures, pertaining to antimalaria engineering works, chiefly drainage.

There are several methods by which the control can be achieved and the method of choice has to be determined in each case. Permanent measures have first preference, wherever the problem lends itself to such treatment. The measures to be adopted and the degree of control aimed at, have a bearing on the size of the community to be protected. The standards for urban control are necessarily higher than for rural areas. Antilarval recurrent measures are more economical for urban areas, whereas for rural areas, antimosquito measures are comparatively less costly. Before the advent of suitable and potent insecticides like pyrethrum and the more recent dichloro-diphenyl-trichlorethane (D.D.T.), control of rural malaria was considered impracticable, but recent advances in technique and material have opened immense possibilities for relief of the long-suffering people in rural areas.

Foothill malaria.—Experimental control of foothill malaria by antilarval methods using paris green was conducted at the Malaria Study Station, Mudigere,

MAP 2a.



and the results have been reported (Sweet and Rao, 1933). While control of malaria by this method was possible, it was found that the cost involved would be prohibitive and therefore not practicable.

Since 1938, series of trials were conducted in the same study station with different naturalistic methods such as: (1) shading, (2) clean-weeding, (3) herbage packing, and (4) sluicing. Similar trials were also conducted in some of the health unit areas situated in the Malnad. The chief recommendation for such methods of control was their simplicity and therefore the possibility of their being adopted by the local people themselves. In actual practice under field conditions, it was however soon found that even under careful supervision by trained personnel, the first three methods could not be depended upon, as it was almost impossible to get the local people interested to do the work systematically. Sluicing, however, was found to be more practicable, but this method had limited application in selected watercourses only and could not, therefore, by itself be depended upon for general application.

With the advent of pyrethrum extract as an insecticide, the position changed considerably. Earlier experiments with it were not however very satisfactory. These trials in the Malnad area were based on the work with *A. culicifacies* and *A. fluviatilis* in the irrigated areas where spraying was repeated once every four days. *A. fluviatilis*, the vector in this area, is known to rest outdoors and therefore this type of spraying did not yield the desired results. This was soon confirmed by Viswanathan *et al.* (1944) in Sirsi and Senior White *et al.* (1945) in the Agency Tracts. The spraying programme, as recommended by these authors, made the method very costly and therefore impracticable for large-scale operations.

The large-scale use of the newer synthetic insecticide D.D.T., with dramatic results during the later stages of the World War II, amply demonstrated that the immense rural malaria problem in India could be effectively tackled. The question, whether the use of this method in foothill malaria could fall within the economic means of the local administrations, still remained.

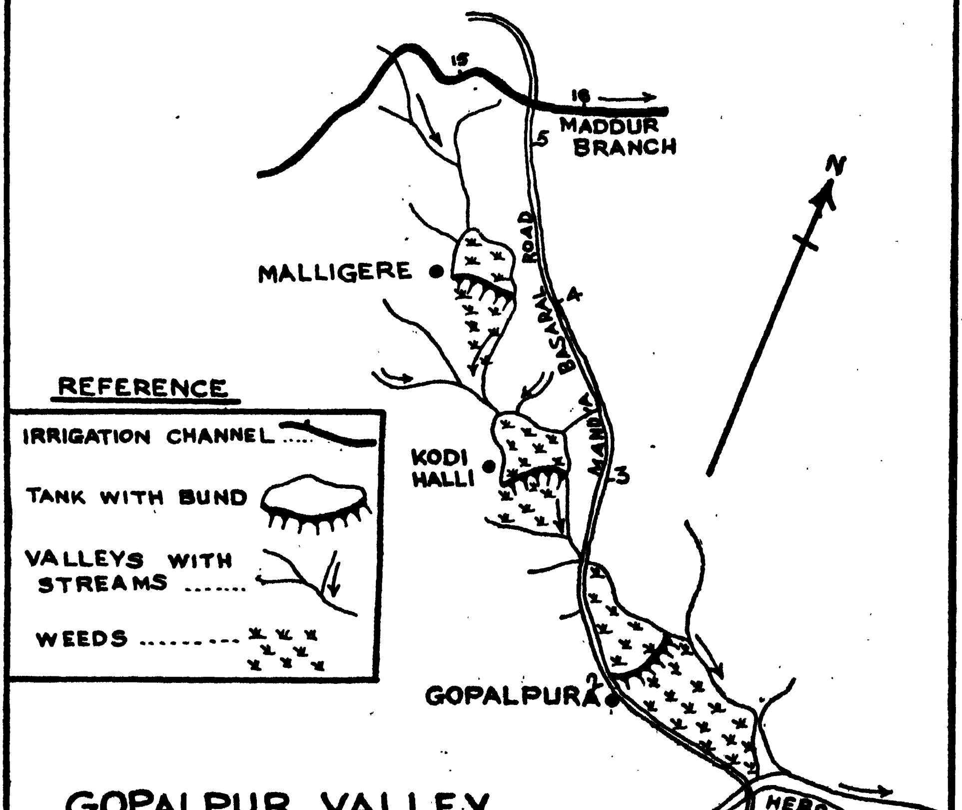
A spraying programme with D.D.T. formulations was organized on an experimental basis in 264 villages in different areas of the Malnad in the Shimoga, Kadur and Hassan districts in 1946-47. Only one round of spraying was applied in the villages in Shimoga and Kadur districts as against three rounds in the villages in Hassan district. The morbidity for malaria was appreciably reduced. It was soon realized that the insect pests were effectively controlled in villages with a single spray resulting in persistent pressure on the administration for a regular D.D.T. spraying programme on a permanent basis. Valuable information as to the working cost became available.

A comprehensive scheme based on health units for combined medical and preventive care of the people in the Malnad at a cost of Rs. 17,35,096 has since been sanctioned by the Government. This scheme, details of which are given in Appendix II, is somewhat comparable to the recommendations of the Health Survey and Development Committee of the Government of India. Spraying work in 27 units (2 in Hassan, 13 in Chickamagalur and 12 in Shimoga districts), modelled on the proposed health units, was started with 2·5 per cent D.D.T.-aeromex emulsion in October 1948.

Irrigation malaria.—A violent outbreak of malaria following the development of irrigation in the Irwin Canal area was discussed by Rao and Nassiruddin (1945),

as also the impracticability of controlling malaria by antilarval methods using paris green by Sweet and Rao (1933). The problem had by 1935 become rather acute

MAP 2b.



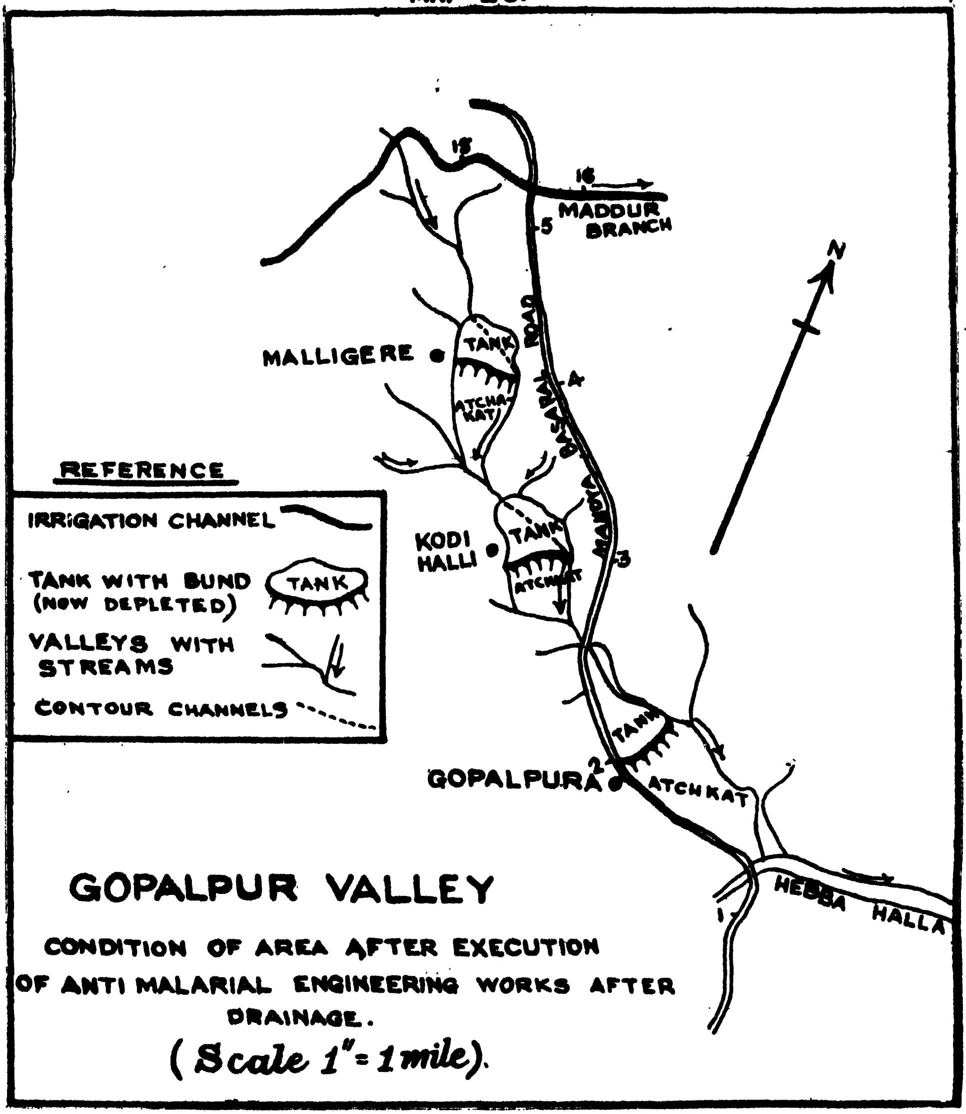
GOPALPUR VALLEY

CONDITIONS OF AREA AFTER THE ADVENT OF IRRIGATION. (BEFORE DRAINAGE)

(Scale 1" = 1 mile)

and a revised scheme for malaria control by pyrethrum spraying was started in a group of 67 villages in Mandya area in 1941.

MAP 2c.


15
16
MADDUR BRANCH
5
N
MALLIGERE
TANK
ATCHA-KAT
BASARAL ROAD
4
MANDYA
REFERENCE
IRRIGATION CHANNEL
TANK WITH BUND (NOW DEPLETED)
TANK
VALLEYS WITH STREAMS
CONTOUR CHANNELS
KODI HALLI
TANK
ATCHKAT
3
TANK
2
GOPALPURA
ATCHKAT
HEBBA HALLA
1
GOPALPUR VALLEY
CONDITION OF AREA AFTER EXECUTION OF ANTI MALARIAL ENGINEERING WORKS AFTER DRAINAGE.
(Scale 1" = 1 mile).

At the same time a committee of officers of health, engineering and revenue departments was set up to investigate the problem in detail and suggest measures for permanent improvement. The terms of reference for this committee were as under :—

1. The officers on special duty should visit the villages that are to be irrigated, and submit proposals regarding the steps to be taken to prevent these villages becoming damp and unhealthy.

2. Alternative proposals to keep off seepage water :—

With special reference to the Lokasara and Sabbanahally villages, where heavy seepage is noticed, the channels may be lined in one of the villages and, in the other, the alternative of intercepting drains of sufficient depth to arrest and lead off the seepage water may be tried. Estimates should be submitted and these alternative proposals tried in two villages to determine which of the two would be more satisfactory. The programme of improvements in these villages should also include proposals for proper drains within the villages so as to keep the same entirely dry.

3. *Village reserve.*—The special officers should also prescribe the village reserve. A limit of two furlongs may be generally kept in view, but this need not be regarded as an inflexible rule. The width of the reserve may vary according to local conditions in each village. These officers should also determine the irrigable areas and blocks. They should consider the possibility of prescribing a semi-dry belt, where fruit trees, vegetables and other lightly irrigated crops can be grown.

4. *Draining of tanks.*—With regard to draining of tanks, the waste weir should be lowered as much as possible, so as to drain the tanks effectively. Contour channels should be excavated to collect and lead off the seepage water to the sluices for distribution to the atchkat. At the same time, the lowest level sluices may be used, if necessary, as auxiliary means of draining the tanks completely.

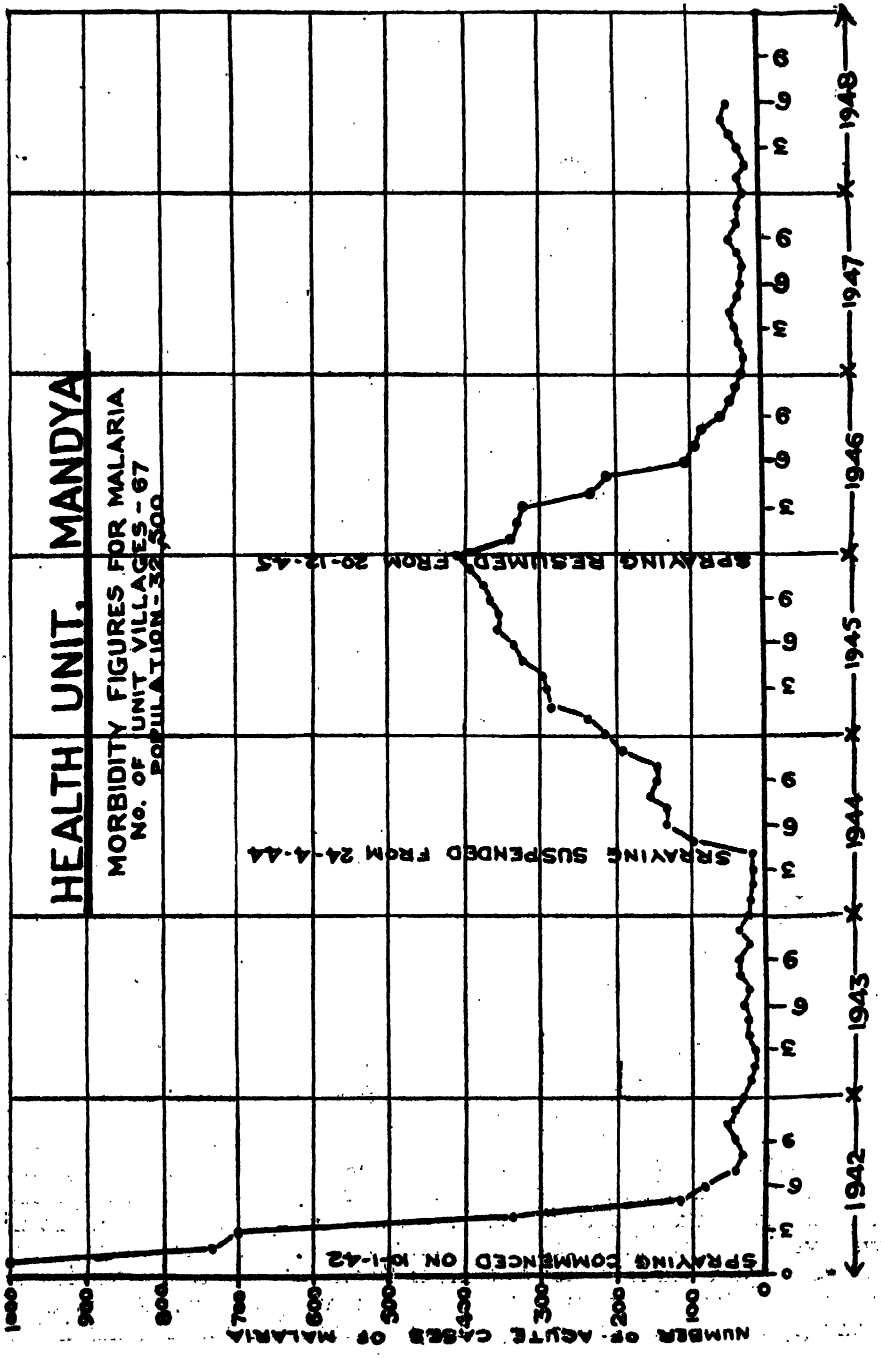
The committee started work in April 1941 with the author as one of its members representing the health department.

The committee inspected 479 villages and drew up detailed recommendations for permanent improvements in respect of each village, under the guidance of the author, on the basis of previous experience of the epidemiology of malaria in the area. These recommendations chiefly aimed at a permanent solution of the problem of malaria in these villages without unduly interfering with the development of irrigation under the project. On the basis of these recommendations, the engineering officer on the committee prepared the projects for drainage (irrigation) and a comprehensive programme of works was worked out. The committee completed its work by the end of 1942 and the several recommendations made by the committee are now under execution. A sample report on a village in the area and a statement giving the comprehensive programme are given in Appendix III.

PERMANENT MEASURES.

The permanent engineering measures were based, as already stated, on the studies carried out at the Nagehahalli Study Station and in Mandya area. Setting

GRAPH I.


HEALTH UNIT, MANDYA
MORBIDITY FIGURES FOR MALARIA
No. OF UNIT VILLAGES - 67
POPULATION - 32,500
SPRAYING COMMENCED ON 10-1-42
SPRAYING SUSPENDED FROM 24-4-44
SPRAYING RESUMED FROM 20-12-45
NUMBER OF ACUTE CASES OF MALARIA
1942
1943
1944
1945
1946
1947
1948

up a lower standard for the degree of control aimed at for rural areas, all measures recommended were based on a flight range of 2 furlongs for the local vector species, *A. culicifacies* and *A. fluviatilis.* The chief recommendations were :—

(1) A dry belt of 2 furlongs round each village, so that no water channels were made available for raising irrigated crops within this zone. Rain-fed dry-crops, which form the staple food of the people, were however continued.

(2) Depletion of all tanks in the area with the exception of a few major tanks. This released the tank beds for economic exploitation, while at the same time arrangements were made for irrigating the lands fed by these tanks from the irrigation surplus water.

(3) Canalization of valleys which were silted and choked with vegetation, and regrading them with a suitable gradient and providing suitable sections to carry the seepage and irrigation surplus water.

(4) Deviation of channels outside the dry belts, wherever possible, or lining them with cement concrete within the dry belt in other cases.

(5) Shifting of small hamlets and villages, adversely situated, to the nearest big villages, where the above protective measures had been provided.

(6) Advantage was taken of the presence of officers of the three departments to include in the recommendations necessary improvement works and other amenities for each village.

At the time the committee was set up, out of a total of 120,000 acres, nearly 60,000 acres in 300 villages had already been brought under cultivation and new channels were being excavated to extend the irrigation. In the villages, where irrigation had been in progress for a period varying from 5 to 10 years, malaria had already established itself as a major health problem.

Fortunately, the Government took a very progressive step in adopting the recommendations of the committee as a purely preventive measure to avoid a repetition of malarial conditions in areas under development schemes, and in fact all the measures referred to above were adopted in 200 villages before water was allowed in the irrigation channels with excellent results (Appendix IV).

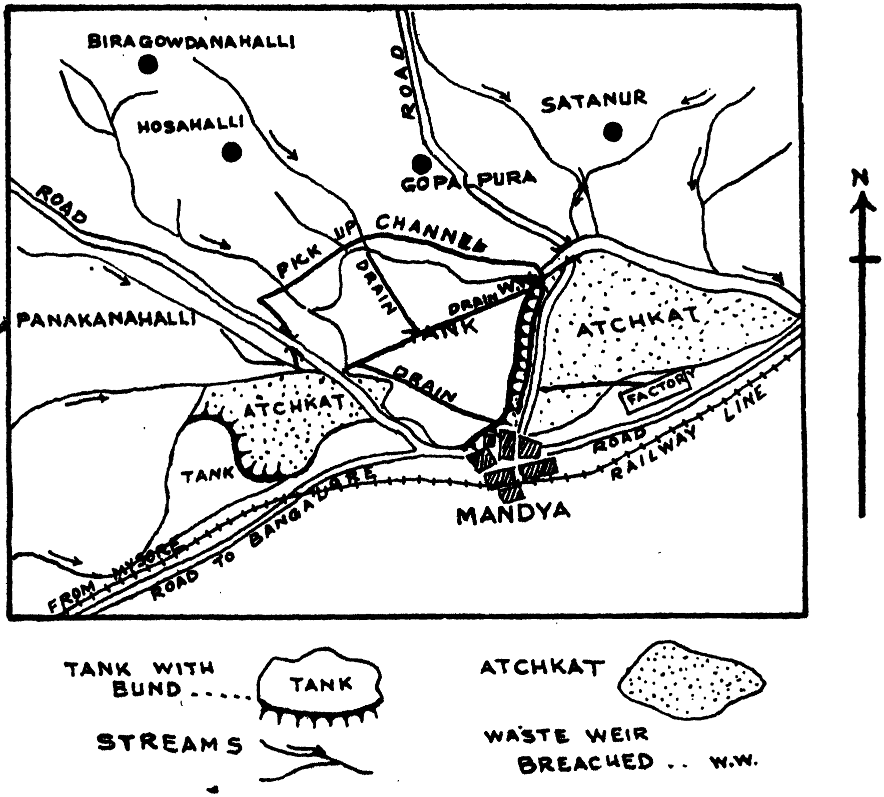
It will be noticed that though these villages have been having the benefit of the irrigation scheme for a period of over 5 to 6 years but contrary to earlier experience malaria has not been a problem. No other antimalaria measures were undertaken in these villages. A slight rise in malaria has been recorded in some villages due to local problems, like seepage areas, valleys and tanks, which have not yet been tackled. This further indicates that the entire area is potentially malarious and would have developed an equally acute problem, but for the timely preventive measures. Their results have more than justified the soundness of the measures adopted and it cannot be sufficiently stressed that any relaxation due to pressure from local interests will be fraught with danger. A set of plans showing (1) Irwin Canal area ; (2) a valley (*a*) condition before canal irrigation,

(*b*) water-logging after irrigation and (*c*) condition after drainage; and (3) detailed plan for depletion of a tank is appended (Maps 1, 2*a*, 2*b*, 2*c* and 3).

MAP 3.

DEPLETION OF MANDYA TANK

(Scale 1" = 1 mile)



Recurrent measures.

As the antimalaria engineering measures above discussed are necessarily a long-term programme, it was found that measures had to be instituted to afford immediate relief from the high incidence of malaria in the area. Experiments were conducted in a group of villages by spraying pyrethrum-kerosene mixture at different intervals. One group of villages was sprayed every 3 days, another

group once in 4 days, a third group once in 5 days and a fourth once in 6 days. At the same time, as these experiments were in progress in the Mandya area, similar works were conducted by Russell and Rao at Puttukottai. In view of there being 2 vectors in this area, viz., *A. culicifacies* and *A. fluviatilis*, it was decided to try the 4th day spraying programme instead of once a week as for *A. culicifacies* only. On the basis of this, an organization was set up for spraying a group of 67 villages.

The number of houses to be sprayed in each village and the total number of such houses in the 67 villages were computed. These villages were split up into convenient groups with one Health Inspector and a number of malaria field workers, so that all the houses in each sub-group could be sprayed in the course of 3 days, assuming that each labourer works for 8 hours a day. The Health Inspector was put in charge of the spraying work and he had to certify the spraying done in his presence. The dosage of application of pyrethrum-kerosene mixture was at the rate of one ounce for every 1,000 c.ft. But in calculating the cubic space, only one-third of the actual height was taken into calculation, on the assumption that only the upper reaches had to be effectively sprayed. This in effect meant that the dosage of application was really 0·33 of an ounce for every 1,000 c.ft. of space.

A locally made handsprayer, designed on the model of the flit pump, was used which, however, required constant repairs.

In order to assess the value of the antimalaria measures undertaken, the following indices were regularly collected :—

(1) Half-yearly spleen rates and (2) morbidity rates.

Spleen surveys were made by the Assistant Medical Officer of Health in charge of each unit during the months of April and October. Representative samples of children under 12 years of age were examined noting down at the same time the different degrees of splenic enlargement. On the basis of these examinations, the spleen rates as also the average enlarged spleen in children of 67 villages have been computed for the different years.

Morbidity rate.—This figure has been arrived at from the data collected by the Health Inspectors during their visits to houses in connection with spraying. Each Inspector recorded all cases with a history of rigors and intermittent fever as acute cases of malaria. The total number of such cases for each round has been computed and the morbidity is expressed as a rate per 100 of population.

Spleen rates for April and October examinations in the 67 villages from 1942 to 1947 are given in Appendix V and morbidity rates in Graph 1.

DISCUSSION.

Before assessing the figures for the spleen and morbidity rates, it is necessary to mention that while the spraying work was going on, antimalaria engineering measures already described were also in progress. In practically the entire area represented by this group of 67 villages, the gross drainage works were completed by the end of 1945, and it would be very difficult to apportion the effects noticed between antimalaria engineering works and pyrethrum spraying.

It will be seen, however, from the spleen figures that the spleen rates have been gradually dropping down from 80 per cent in 1942 to 48·6 per cent in 1947. At the same time the average enlarged spleen also has come down from 3·18 to 2·07. There is therefore no doubt that the malaria situation in the area under discussion has significantly come down. This is also reflected in the Graph for the morbidity rates. But there are so many fallacies in regard to the definition of an acute case of malaria and the method of collection of these figures that one cannot rely too much on these rates, but they only serve to indicate the trend of events. The spleen rates however do not substantiate the fall in the morbidity as indicated in the Graph for the morbidity rates. It has also not been possible to statistically correlate the trend in the spleen rates with the morbidity rates.

In Appendix V, birth rates and death rates for this group of 67 villages are also given for the period 1942 to 1947. The registration of births and deaths is not satisfactory as revealed by the birth rate and death rate for the State for 1947 (15·3 and 11·2 per thousand respectively). The figures are collected from the usual agencies for the purpose and are used to indicate the general trends only. Except for a sudden rise in the birth rate in the year 1943, it is seen that the birth rate which was 15·7 in 1942 has gradually risen up to 26 in 1947, while at the same time the death rate which was 22 in 1942 has come down to 17.

This trend is in keeping with the fall in the spleen rates showing a general all-round improvement in the health of the people. Comparing the spleen rates in 67 villages with those of Malavalli Health Unit, where irrigation was extended under controlled conditions (Appendix IV), it will be seen that the malaria problem, which had assumed such enormous proportions in the 67 villages, does not show itself in the new area, in spite of several seasons of irrigation. This is a significant fact, justifying several permanent measures recommended for execution concurrently with the development of irrigation.

FUTURE EXPANSION.

The results of control work undertaken so far have created a pressing demand for the extension of the scope of this work to include all other affected areas in the State. The activities have already brought an undue strain on the present trained staff. Any further extension is definitely linked with two fundamental requirements: (1) trained technical staff for research, surveys and direction and (2) the expansion of the peripheral health organization, i.e., health centres to cover the affected population.

Staff specially trained in malaria work is necessary at each level. Initial surveys and investigations are necessary to formulate programmes for further work and this means technical staff at the centre, as well as at the secondary centres. It is necessary, therefore, that suitable staff should be trained in malaria work and such staff should look up to their future only in this branch of work. Such staff should be attached to the secondary health centres and work in each case under the administrative control of the Medical Officers of Health in charge of the centres. The technical direction should continue from the centre.

It is equally important and in fact essential for the proper functioning and healthy development of antimalaria work to maintain continuous research. Such

an organization will not only maintain contact with day-to-day developments, but will conduct surveys and obtain the lacking details of information in respect of each area. A statement of skeleton organization for the State is given in Appendix VI.

ACKNOWLEDGMENT.

The author is grateful to the Director of Public Health for permitting him to send this paper for publication. He also wishes to acknowledge the unstinted co-operation of the assistant engineers, who were associated with him throughout the period of this work in the planning and later in the preparation of these estimates.

REFERENCES.

Rao, B. A., and Nassiruddin, M. (1945). *J. Mal. Inst. Ind.*, **6**, 2, pp. 109–128.
Senior White, R., Ghosh, A. R., and Rao, V. V. (1945). *Ibid.*, **6**, 2, pp. 129–164.
Sweet, W. C. (1933) ... *Rec. Mal. Surv. Ind.*, **3**, 4, pp. 663–687.
Sweet, W. C., and Rao, B. A. (1933). *Ibid.*, **3**, 4, pp. 689–718.
Viswanathan, D. K., Ramachandra Rao, T., and Rama Rao, T. S. (1944). *J. Mal. Inst. Ind.*, **5**, 4, pp. 449–466.

APPENDIX I.

Health units (malaria) in Mysore State.

Serial No.	Name of district.	Number of primary centres.	Number of secondary centres.	Number of villages.	Population.	Budget.
						Rs.
1	Mysore	6	2	105	60,000	73,000
2	Hassan	4	0	78	18,200	18,000
3	Chitaldrug ...	1	1	32	17,000	17,000
4	Mandya ...	20	4	496	291,000	3,80,000
5	Kadur	14	...	348	106,000	82,000
6	Bangalore ...	1	...	8	4,000	2,000
7	Shimoga ...	14	2	468	89,000	1,15,000
8	Tumkur ...	4	1	44	12,100	34,000
	Total ...	64	10	1,579	597,300	7,21,000

APPENDIX II.

Financial statement for starting 81 primary and 16 secondary centres in Malnad districts.

STAFF FOR PRIMARY CENTRE—

One assistant medical officer of health in the scale of Rs. 100–5–175–10–225, F.T.A. Rs. 30.
Two junior health inspectors in the scale of Rs. 45–3–90, F.T.A. Rs. 8.
One clerk in the scale of Rs. 40–2–50/E.B. 3–80.
Three midwives in the scale of Rs. 35–2–55, F.T.A. Rs. 8.
One compounder in the scale of Rs. 30–2–50.
One surgical attendant in the scale of Rs. 18–½–22.
One waterman in the scale of Rs. 16–½–20.
Two peons in the scale of Rs. 14–½–18.
Eight malaria field workers in the scale of Rs. 14–½–18.

STAFF FOR SECONDARY CENTRE—

One health officer, II class, in the scale of Rs. 200–10–300–20–500, F.T.A. 75.
One senior health inspector in the scale of Rs. 80–4–120, F.T.A. 12.
Two public health nurses in the scale of Rs. 60–5–100, F.T.A. 30.
One typist clerk in the scale of Rs. 45–3–60–4–100.
Four peons in the scale of Rs. 14–½–18.

RESERVE STAFF—

One junior health inspector in the scale of Rs. 45–3–90, F.T.A. Rs. 8.
One midwife in the scale of Rs. 35–2–55, F.T.A. Rs. 8.

	Rs.
Cost of 81 primary centres	8,92,113
Cost of 16 secondary centres	2,03,072
Recurring expenditure for D.D.T., solvent drugs, etc.	4,50,479

ABSTRACT.

	Rs.
Recurring expenditure :	
(*a*) Salaries and establishment	11,96,126
(*b*) D.D.T., drugs, etc.	4,50,479
	16,46,605
Non-recurring expenditure	2,02,216
TOTAL	18,48,821
Deduct cost of existing 28 health units and 53 dispensaries	4,74,134
NET EXTRA COST	13,74,687

F.T.A. = Field and travelling allowances.

Secondary and primary centres by districts.

District.	Number of secondary centre.	Number of primary centre.	Number of villages.
1. Hassan ...	3	19	537
2. Chickamagalur ...	6	32	427
3. Shimoga ...	7	30	354

APPENDIX III.

Programme of antimalaria engineering works.

	Approximate cost in lakhs. Rs.
1. Canalization of valleys—100 valleys	10
2. Depletion of tanks—150 tanks	7
3. Creation of dry belt around villages { 150 villages in old area ... ... ; 100 villages in the new area ... }	2
4. Shifting of hamlets and villages—100 hamlets at 20 houses per hamlet—2,000 houses	6½
5. Treatment of major tanks :	
(a) Full depletion of two tanks	3 } 5
(b) Partial depletion of two tanks	2 }
6. 2nd stage : Lining of channels and valleys within two-furlong zone of villages ...	4½
TOTAL	35

The works are in progress. The outlay to date is about Rs. 14 lakhs.

APPENDIX IV.

Detailed statement of spleen examination in the area brought under irrigation since* 1942.

Unit.	Quarter ending	Number examined.	Number with enlarged spleen.	PALPABLE SPLEENS. P	1	2	3	4	5	6	Spleen rate per cent.	Average enlarged spleen.
Malavalli ...	Oct. 1947	2,005	122	81	41	...	...	...	...	...	6·08	1·3
	Apr. 1948	1,310	60	42	19	...	...	...	...	...	4·57	1·3
	Oct. 1948	2,368	80	61	17	2	...	...	...	...	3·37	1·2
Dugganahalli ...	Oct. 1947	1,531	378	54	79	133	92	4	...	...	24·68	2·6
	Apr.† 1948	...	...	...	...	...	...	...	...	...	...	...
	Oct. 1948	1,507	169	88	44	25	6	1	4	1	11·01	1·8
Kirgaval ...	Oct. 1947	2,125	369	335	27	7	...	...	...	...	17·3	1·1
	Apr. 1948	2,692	176	156	18	1	1	...	...	...	6·5	1·1
	Oct. 1948	1,799	378	368	10	...	...	...	...	...	21·01	1·02
Agasanapura ...	Oct. 1947	2,376	17	8	5	3	1	...	...	...	0·71	1·8
	Apr. 1948	1,936	7	...	2	5	...	...	...	...	0·36	2·7
	Oct. 1948	2,388	13	5	5	2	1	...	...	...	0·54	1·9

* This area forms part of the Irwin Canal Project where irrigation was developed along with drainage and other permanent antimalaria measures. The spleen rates show no increase in malaria.

† Figures not available.

APPENDIX V.

Detailed statement of spleen examination in the area brought under irrigation since 1942, with birth rate and death rate.

Month.	Number examined.	Number with enlarged spleen.	P	1	2	3	4	Average enlarged spleen.	Spleen rate per cent.	Birth rate per thousand.	Death rate per thousand.
Apr. 1942 ...	3,051	2,586	178	606	545	885	372	3·25	84·7	15·7	22·7
Oct. 1942 ...	2,876	2,129	178	610	480	726	135	3·01	74·7		
Mar. 1943 ...	2,910	1,987	406	660	558	345	18	2·40	68·2	34·4	25·7
Nov. 1943 ...	3,081	2,114	596	606	652	206	54	2·21	68·6		
May 1944 ...	3,136	1,888	295	507	566	460	60	2·7	60·2	24·8	21·2
Jun. 1945 ...	2,895	2,010	424	506	464	413	203	2·02	69·4		
Nov. 1945 ...	3,185	2,170	406	714	504	442	104	2·50	68·0	18·0	18·3
May 1946 ...	3,158	2,176	640	653	402	330	151	2·20	68·0		
Oct. 1946 ...	3,353	1,872	416	746	391	229	90	2·07	52·3	19·1	17·3
Apr. 1947 ...	3,423	1,695	583	547	304	177	84	2·19	49·5		
Oct. 1947 ...	3,423	1,611	593	578	221	170	49	2·07	48·6	26·0	17·0

APPENDIX VI.

DIRECTOR OF PUBLIC HEALTH.

MALARIOLOGIST.

Deputy Malariologist (Staff).

Entomologist (Staff).

Public Health Engineer (Staff).

Laboratory (Staff).

DISTRICTS (6).

DISTRICT HEALTH OFFICER.

Assistant Malariologist.

(II Class Health Officer.)

Secondary Centres.

Medical Officer of Health.

Assistant Entomologist (Staff).

Malaria Assistant (III Class Health Officer) (Staff).

Primary Centres.

Assistant Medical Officer of Health.

Health Inspector.

Insect Collectors.

Malaria Field Workers.

Indian Journal of Malariology, 2, 4, December 1948.

A PRELIMINARY NOTE ON ANTIMOSQUITO OPERATIONS IN CUTTACK TOWN.

BY

LIEUT.-COLONEL B. N. HAJRA, M.SC., M.B., M.R.C.P. (Lond.)
(Director of Health and Inspector-General of Prisons, Orissa.)

[February 3, 1949.]

CUTTACK, a divisional town till 1936, rapidly increased its importance when it became the capital of the newly constituted province of Orissa. Its population, which was 65,263 in 1931, increased to 74,291 in 1941 and owing to further development since 1941, the present population exceeds one hundred thousand.

The civic improvement of the town was taken up for consideration soon after the formation of the province but a full-fledged scheme could not be worked out for various reasons: (1) the permanent location of the capital, whether at Cuttack or at any other place, could not be finally decided till recently; (2) on the outbreak of the war, all engineering schemes had necessarily to be held up, and (3) shortage of building material and technical personnel, besides the execution of more important works like building the new capital and the Hirakud Project, served to delay exclusive attention being paid to the improvement of the town.

There have been other difficulties in the way of its improvement. Cuttack is situated in the narrow strip of land between the River Mahanadi and its first southern branch, Kathjuri. Due to the silting of the rivers occurring during the process of delta formation, the river-bed levels have gradually risen in places actually above the town level, rendering the low-lying areas subject to flooding. This possibility has been avoided by the construction of embankments along both the rivers.

The embankments have served to raise the river-beds still further by restricting the flow, thereby actuating the eventual threat of flood, and besides effective drainage of the town is not easily obtained. During the rains, the town gets completely waterlogged, while in the dry season the bulk of the sullage water is discharged into the few main *kutcha* drains which in most cases end blindly in the outskirts of the town.

Following the age-old custom of digging tanks for pleasure or on philanthropic or religious grounds, tanks constructed everywhere have now become almost

disused and overgrown with aquatic vegetation and certain species of anopheline mosquitoes, particularly *A. annularis*, breed in them.

Conditions required for the spread of malaria and filaria are present and it has been shown that *A. annularis* is the main malaria vector of Orissa plains and that, though pre-eminently a zoophilic insect, it causes epidemics or even maintains endemic conditions in Orissa by sheer force of numbers (Senior White *et al.*, 1943). The explanation lies in the fact that in Orissa edaphic conditions favour a particularly heavy growth of aquatic vegetation in the tanks, among which the larvæ of *A. annularis* find a perpetual nidus (Senior White and Venkat Rao, 1946).

Malaria is not always a major problem in Cuttack, though it is highly endemic in the eastern regions of the district. But, there is a sufficiently high level of endemicity, over which periodical epidemics are superimposed at irregular intervals. The more important problem is filariasis, which is present to a very marked extent. Though the economic importance of malaria has long been recognized, that of filariasis has only been stressed recently by Pattabhi Sitaramayya (1948), who emphasized that this disease is reducing the work-coefficient and the man-hours of the nation. Only one form of filariasis, carried by *Wuchereria bancrofti*, is present in Cuttack, while the rural filariasis, carried by *Wuchereria malayi*, though present in rural areas not far off, is conspicuous by its absence here. The reason appears to be that the carrier of the former, *Culex fatigans*, exists in enormous numbers with its nidus in the large number of stagnant or slow-moving sullage waters, whereas the carrier of the latter, *M. annulifera*, is practically absent, owing to the scarcity of Pistia in the tanks, where alone it is capable of breeding.

The Cuttack Municipality made serious efforts in previous years to reduce mosquito nuisance by oiling the breeding places but their efforts failed to make a marked impression. This may be partly due to the absence of trained supervisors during the war period but it is mainly due to the fact that nearly every house has one or more breeding places in drains or cesspools inside the compound and it is very difficult to oil every such breeding place regularly every week. There are also about 5,000 wells in the town area, most of which are in a disused condition and breed *C. fatigans* in large numbers. Even under careful supervision, their regular weekly treatment would be exceedingly difficult. The mosquito nuisance and with it the threat of increase in the incidence of malaria and filariasis has so increased in the post-war years that a serious attempt had to be made to improve the situation, irrespective of considerations of finance.

It is well known that malaria exists over a very large part of the province and constitutes the major public health problem and that filariasis exists over a wide area, specially in the plains and coastal strips. Attempts to control these diseases on a large scale have to be made sooner or later and, in order to infuse confidence in the public, it is necessary to demonstrate the efficacy of anti-mosquito operations and to 'make a thorough job of it' in a city like Cuttack so that funds for extending the operations in the interior may be readily obtained.

The anti-mosquito scheme at Cuttack was based on such considerations as those mentioned above. Antilarval measures alone have not proved economical in the past and are not likely to be so in the future. Anti-adult spraying in houses

with D.D.T. is also likely to be too costly. The usual interval between each D.D.T. spraying is six weeks in the case of Anopheles, which means about eight to nine sprays annually. Culicine mosquitoes are more resistant to D.D.T. than Anopheles (Puri, 1947) and might require spraying once a month. The cost of spraying all the 10,000 and odd houses in Cuttack twelve times annually would be so high that any such proposal is likely to be rejected on financial grounds. Therefore, it was proposed to spray the entire town against adult mosquitoes four times in a year, during periods of heavy prevalence of *A. annularis* and *C. fatigans*, supplemented with antilarval work in certain selected areas.

The periods of anti-adult spraying were fixed as follows :—

March-April
September-October
November-December
January-February

The unusual rise in the *A. annularis* density which usually occurs towards the end of September and is followed by a marked increase in the malaria incidence during the following months was sought to be controlled by the spraying in September-October. After the close of rainy season, *C. fatigans* increases in numbers, *A. annularis* being still present in sufficient numbers and their control is to be secured with the November-December spraying. The next two sprayings are intended against *C. fatigans* only, as *A. annularis* prevalence subsides during that period. No spraying was provided for the control of *C. fatigans* during the height of the rainy season as the breeding places of *C. fatigans* get flushed off by heavy and continuous rains (the average annual rainfall at Cuttack is just over 60 inches).

Accordingly, a scheme involving an annual expenditure of Rs. 1,07,000 has been sanctioned by the Government of Orissa and it was put into operation towards the end of March 1948.

For house-spraying, the 12 wards of the municipality were divided into 24 blocks and each block was entrusted to a gang of one supervisor and three coolies. Thus, spraying was started simultaneously in 24 localities of the town and it was possible to complete spraying the whole town in about seven weeks. Meanwhile, antilarval work was intensified. One Health Inspector was in charge of antilarval work and another in charge of anti-adult spraying, while one Sub-Assistant Surgeon was in ultimate charge of the whole work.

By the end of the first anti-adult spraying, remarkable results were observed. The town became almost mosquito-free and the public, who discarded their mosquito nets for the first time in their lives, expressed their satisfaction in no uncertain terms. But, the breeding, though diminished, still continued to such an extent that it was feared that, without another spraying immediately following the first, mosquitoes would soon return and the freedom from mosquitoes, which the public had just enjoyed, might be a short-lived affair. Such a situation would augur ill for the future of similar operations in the province. Probably, the number of adult mosquitoes was so very heavy that some of them had, for want of resting space in houses and cowsheds, to spend the day time outside the houses which are

not sprayed and these were responsible for the continued presence of larvæ in breeding places. Actually, *C. fatigans* were observed resting on the sides of deep drains and under small culverts on a number of occasions. Therefore, it was decided to re-spray the entire town in May-June in spite of the cost immediately after the first spray was completed. This had the desired effect and mosquito nuisance appeared to have almost become a thing of the past.

No provision was made, as already stated, for another house-spraying till mid-September but it was found that during July and August of 1948, the rains were not as heavy or as continuous as they had been in previous years. A decrease in rainfall and occasional showers, far from flushing the breeding places, tended to increase the mosquito breeding places. Therefore, the spraying programme was modified and the autumnal spraying was put forward to August-September. Subsequent heavy rains of the north-west monsoon rendered it unnecessary to accelerate the next spraying, which began in mid-November according to schedule and completed by the end of January.

One difficulty encountered during the course of house-spraying may be mentioned here. Most of the poor people here have mud-walled houses, and they are in the habit of renewing the mud-plaster at least once annually, usually before the Dipavali festival. If the D.D.T. deposit is covered by fresh coating of mud, it is, as is well known, not accessible to the resting mosquitoes and, therefore, becomes useless. Re-spraying all such houses is both costly and impracticable. The spraying was, therefore, done in many cases after mud-plastering but this was not possible in the case of several houses. This, however, does not appear to have any marked effect on the general results as shown below and the man-hour mosquito catch continued to be low.

The results have been quite encouraging. The adult mosquito man-hour catch has been reduced from about 100 to less than 5 and, even in mid-December, when mosquito nuisance usually became intolerable and people dreaded to sleep without a net, the catch remained usually at the very low level of 2 to 3 per man-hour.

Owing to the rise in cost of materials and labour and also due to an additional spraying not contemplated in the original programme, the estimate exceeded by about Rs. 20,000, but it is gratifying to note that the Government are sufficiently impressed to sanction the additional expenditure.

The effects of these operations on the reduction of malaria and filariasis cannot be judged so soon but it is hoped that at the end of three years the author would be able to publish all the relevant information, showing the reduction in numbers of mosquitoes, in spleen rates and in the incidence of these two dreaded diseases. That is also his excuse for not furnishing details in this note.

The material used in antilarval work was 'Malariol B' plus 5 per cent D.D.T. in drains and cesspools applied at the rate of 4 to 5 gallons of the solution per acre of water surface. In tanks and ponds, which are used by the people for domestic purposes, Geigy malaria spray 50 per cent D.D.T. suspension powder, marketed by Messrs. Geigy Insecticides Limited of Bombay, was sprayed at the rate of 2/3 lb. per acre added to 30 gallons of water. This strength was observed to leave fish unaffected.

For house-spraying, Geigy malaria spray has been exclusively used on account of its ease in preparing the suspension and spraying of houses. This material is used in the standard proportion recommended by the manufacturers, viz., one pound of the powder added to 5 gallons of water and sprayed over approximately 6,000 square feet, leaving a deposit of about 38 mg. of D.D.T. per square foot.

The total cost of these operations is expected to amount to Rs. 1,25,000 annually, which means a *per capita* expenditure of about Re. 1-4-0 a year. This, it is claimed, is not too high if thereby malaria and filariasis can be effectively controlled and freedom from general mosquito nuisance ensured. In the present case, the success achieved at Cuttack has become so popular that other towns and malarious tracts in rural areas are clamouring for extending the operations to their areas. This alone can be claimed as true indication of the measure of the success obtained so far at Cuttack. On completion of the drainage scheme now under consideration, anti-mosquito work on the present scale would necessarily be reduced.

The author takes this opportunity to thank the Government of Orissa for freely sanctioning this expenditure as soon as it was asked for. He wishes to acknowledge the whole-hearted co-operation received from his assistants and subordinates, without which the scheme might have ended in failure. He also wishes to place on record his appreciation of the services rendered by Mr. V. Venkat Rao of Messrs. Geigy Insecticides Limited in this connection.

REFERENCES.

PATTABHI SITARAMAYYA (1948) ... Presidential address at the 55th session of Indian National Congress, Jaipur.

PURI, I. M. (1947) ... *Ind. J. Mal.*, **1**, 1, pp. 211–220.

SENIOR WHITE, R., ADHIKARI, A. K., RAMAKRISHNA, V., and ROY, B. B. (1943). *J. Mal. Inst. Ind.*, **5**, 2, pp. 159–186.

SENIOR WHITE, R., and VENKAT RAO, V. (1946). *Ibid.*, **6**, 3, pp. 297–308.

Indian Journal of Malariology, 2, 4, *December 1948*.

OBSERVATIONS ON THE VECTORS OF MALARIA IN KHANDWA TAHSIL, NIMAR DISTRICT, CENTRAL PROVINCES, AND NOTES ON THE SEASONAL INFECTIVITY OF ANOPHELES.

BY

R. SUBRAMANIAN

AND

D. T. DIXIT.

(*Malaria Organization, C. P. and Berar.*)

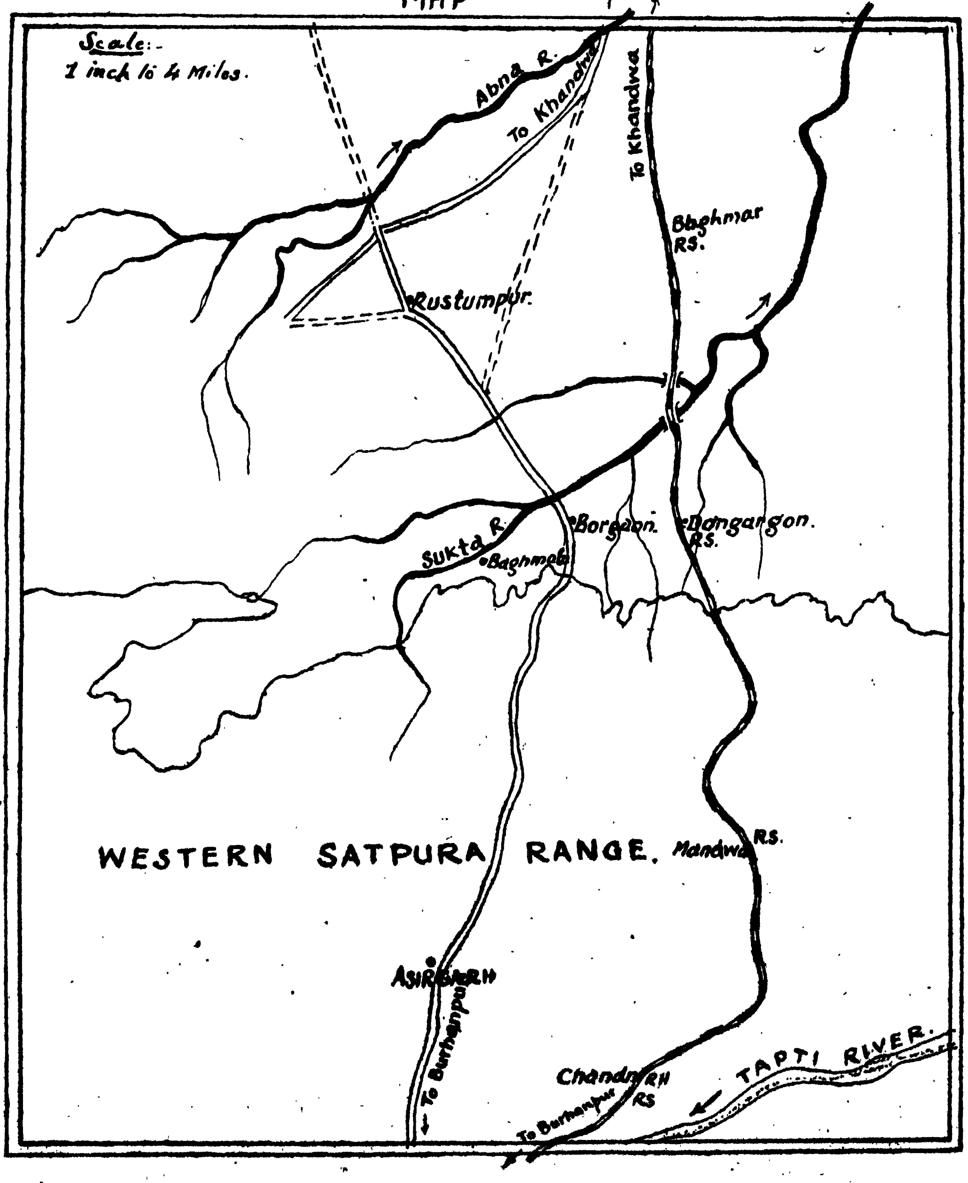
[February 8, 1949.]

KHANDWA TAHSIL is the North-Western Tahsil of the Nimar District in the Central Provinces, lying between 21° 31′ and 22° 20′ north and 76° 4′ and 76° 59′ east. The Nerbudda River borders the tahsil on the north, and separates it from Holkar territory. To the east lies Harsud Tahsil of Nimar District, to the west Indore State, and to the south Burhanpur Tahsil of Nimar District. Traversing the southern border of Khandwa Tahsil from east to west is the main range of the Western Satpuras. The features of this range are a succession of low hills and shallow valleys of heavy black soil covered with forest and long grass. North of this is the fertile plain comprising the valleys of the Abna and Sukta rivers. This contains no forest or hills of any size but the ground undulates continually from valleys with a central stream up to broad ridges. The basin of the Sukta River stretches southward to the foot of the Satpuras. The line of country where the hill and valley gradually merge is traversed by innumerable small streams and watercourses. Here the small occupied areas are closely fringed by long grass and scrub and are intensely malarious. The villages located in the Western Satpura Range also show a very high rate of endemic malaria. In the cultivated plains, north of the range of hills, there is no endemic malaria.

The investigations were carried out in three different regions during the period July 1948 to January 1949. One region lies in the Western Satpura Range itself, in Ashirgarh, 850 feet high from the base and 2,283 feet above sea level. The

second region is where the Satpura Range merges with the plain of Khandwa Tahsil on the banks of the River Sukta. The third region is on the plains of Khandwa Tahsil between Sukta and Abna rivers (Village Rustampur). The places are shown in the Map.

MAP



Senior White in one of his communications addressed to the Principal Medical and Health Officer, G. I. P. Railway, on the subject 'Anti-malaria measures, Chandni-Dongargaon section*' says 'all things point to a transmission season from July to November. Rainfall is 40 to 50 inches with the monsoon starting in the latter half of June. There is no rice land. *A. fluviatilis*, a notoriously efficient malaria vector, finds suitable breeding places in streams and nalas there. None the less in view of the fact that Kenrick (1911), who is the only worker who has ever investigated the Western C. P., attributed transmission to *A. culicifacies* in the not very distant Melghat District, it would be most advisable to discover the actual vector of this ghat by dissections of a large number of the possible vector species'.

NATURAL INFECTION IN ANOPHELES.

From the three regions mentioned earlier, specimens of Anopheles caught were examined for malarial infection. Altogether 8,943 specimens as shown in Table I were examined.

TABLE I.

Anopheline mosquitoes examined for malarial infection.

Species.	Number dissected.
A. culicifacies	7,337
A. fluviatilis	1,324
A. stephensi	113
A. annularis	11
A. subpictus	30
A. theobaldi	102
A. turkhudi	5
A. varuna	12
A. splendidus	9
TOTAL	8,943

Of the 9 species examined, two showed natural infection with malaria parasites as shown in Table II. The rest were negative. The infection rates of 0·21 and 1·28 in *A. culicifacies* and *A. fluviatilis* respectively indicate that both should be regarded as vectors with *A. culicifacies* playing a minor rôle.

* Chandni Railway Station is 5 miles from Ashirgarh in Western Satpura Range. Dongargaon is located where the Satpura Range merges with the plain of the Khandwa Tahsil.

TABLE II.

Details of positive findings.

Species.	Number dissected.	Number with sporozoite infection of salivary glands.	Infection rate, per cent.
A. culicifacies ...	7,337	16	0·21
A. fluviatilis ...	1,324	17	1·28

SEASONAL INCIDENCE OF INFECTION IN ANOPHELES.

In order to ascertain the seasonal incidence of infection in the vector, the findings relating to the two species namely *A. culicifacies* and *A. fluviatilis* have been analysed to bring out the monthly incidence of infection.

SEASONAL INCIDENCE OF INFECTION IN *A. CULICIFACIES*.

The authors' observations on *A. culicifacies* are given in Table III. No infections were found in July and August. The first infection in *A. culicifacies* was encountered on September 28, 1948, at Village Rustampur in the plains of Khandwa Tahsil in a human dwelling. The infection rate is low as was found by Senior White (1940) in Eastern Satpura Range.

TABLE III.

Incidence of natural infection in A. culicifacies.

Month.	Number dissected.	Number with sporozoites in salivary gland.	Infection rate, per cent.
1948.			
Jul.	364	0	0·00
Aug.	251	0	0·00
Sep.	527	1	0·18
Oct.	468	2	0·42
Nov.	2,155	8	0·37
Dec.	2,086	2	0·09
1949.			
Jan.	1,486	3	0·20
TOTAL ...	7,337	16	0·21

However, the infectivity rate in *A. culicifacies* reaches its maximum in October and November.

SEASONAL INCIDENCE OF INFECTION IN *A. FLUVIATILIS.*

The authors' observations are shown in Table IV.

No adult *A. fluviatilis* was caught in July. In August very few were collected in the catching stations. The first natural infection in *A. fluviatilis* was encountered on October 29, 1948. This specimen was collected from Village Ashirgarh in Western Satpura Range. The infectivity rate in *A. fluviatilis* is higher than that obtained in *A. culicifacies.*

TABLE IV.

Incidence of natural infection in A. fluviatilis.

Month.	Number dissected.	Number with sporozoites in salivary gland.	Infection rate, per cent.
1948.			
Jul.	0	0	0·00
Aug.	4	0	0·00
Sep.	62	0	0·00
Oct.	100	1	0·97
Nov.	352	7	2·00
Dec.	425	5	1·17
1949.			
Jan.	381	4	1·00
TOTAL ...	1,324	17	1·28

It can be safely assumed that *A. culicifacies* initiates the transmission of malaria in the second half of September with *A. fluviatilis* closely following in

October. The high infection rates jointly obtained in both *A. culicifacies* and *A. fluviatilis* during October and November conform with the generally accepted view that the transmission of malaria in this area is most frequent during the season following the monsoon.

The presentation of the seasonal incidence of natural infection in *A. culicifacies* and *A. fluviatilis* on a regional basis (as shown in Tables V, VI and VII) brings out certain points of interest.

TABLE V.

Ashirgarh area (Western Satpura Range).

Month.	*A. culicifacies.*			*A. fluviatilis.*		
	Number dissected.	Number positive for sporozoites.	Infection rate per cent.	Number dissected.	Number positive for sporozoites.	Infection rate per cent.
1948.						
Jul. ...	52	0	0	*Nil.*	...	...
Aug. ...	57	0	0	1	0	0·0
Sep. ...	364	0	0	56	0	0·0
Oct. ...	169	0	0	53	1	1·9
Nov. ...	891	3	0·3	169	6	3·8
Dec. ...	258	0	0	119	2	1·7
1949.						
Jan. ...	154	0	0	167	1	0·6
TOTAL ...	1,945	3	0·15	565	10	1·76

TABLE VI.

Bagmala-Dongargaon area (where Satpura Range merges with the plains of Khandwa Tahsil).

Month.	*A. culicifacies.* Number dissected.	Number positive for sporozoites.	Infection rate per cent.	*A. fluviatilis.* Number dissected.	Number positive for sporozoites.	Infection rate per cent.
1948.						
Jul. ...	270	0	...	*Nil.*	...	...
Aug. ...	140	0	...	3	0	0
Sep. ...	151	0	...	6	0	0
Oct. ...	216	2	0·9	46	0	0
Nov. ...	928	3	0·3	173	1	0·62
Dec. ...	1,584	2	0·12	294	3	1·00
1949.						
Jan. ...	1,104	2	0·18	204	3	1·4
TOTAL ...	4,393	9	0·20	726	7	0·96

TABLE VII.

Rustampur area (plains of Khandwa Tahsil).

Month.	*A. culicifacies.* Number dissected.	Number positive for sporozoites.	Infection rate per cent.	*A. fluviatilis.* Number dissected.	Number positive for sporozoites.	Infection rate per cent.
1948.						
Jul. ...	42	0	0·0	*Nil.*	...	...
Aug. ...	54	0	0·0	*Nil.*	...	...
Sep. ...	12	1	8·3	*Nil.*	...	...
Oct. ...	83	0	0·0	1	0	0
Nov. ...	336	2	0·5	10	0	0
Dec. ...	244	0	0·0	12	0	0
1949.						
Jan. ...	228	1	0·43	10	0	0
TOTAL ...	999	4	0·40	33	0	0

In the Western Satpura Range, very few *A. culicifacies* with natural infection was encountered and that too in one month only. Whereas infectivity rate in *A. fluviatilis* was highest obtained, as compared to other regions.

In the region where the Satpura Range merges with the plains of Khandwa Tahsil, the infectivity rate in *A. culicifacies* was slightly higher than that obtained in Ashirgarh. On the other hand in *A. fluviatilis* it was one half of that obtained at Ashirgarh.

In the plains, the findings are much more interesting. With comparatively fewer dissections carried out in *A. culicifacies*, the infectivity rate is the highest as compared to other regions. In July, August and September, no *A. fluviatilis* was collected in the plains. From October to December very few *A. fluviatilis* were encountered. None of them showed natural infection (Graph).

Goverdhan (1912) states, 'certain species are always found associated with high endemic malaria in C. P. They are *A. fluviatilis*, *A. theobaldi*, *A. jeyporiensis* and *A. culicifacies*. The first three are rarely met with in healthy areas, e.g. open parts of the plateau districts, but are constantly met with in the jungle villages. *A. culicifacies*, however, is encountered both in open healthy areas as well as highly malarious localities'.

In this area *A. jeyporiensis* was not encountered at all. As regards *A. theobaldi* very few specimens were caught. Majority of them were collected either from the Satpura Range or from the region where the range merges with the plain. The density of *A. fluviatilis* was the greatest in the highly endemic areas, viz. the Western Satpura Range and where it merges with the plain. In the valley between Sukta and Abna rivers, *A. fluviatilis* density was low, *A. culicifacies* predominating.

SUMMARY.

Out of the 9 species of Anopheles examined for malarial infection in Western C. P., two species namely *A. culicifacies* and *A. fluviatilis* were found naturally infected. The sporozoite rate in them were 0·21 and 1·28 per cent respectively.

There is practically no transmission of malaria in July and August. The transmission commences in September and continues to January.

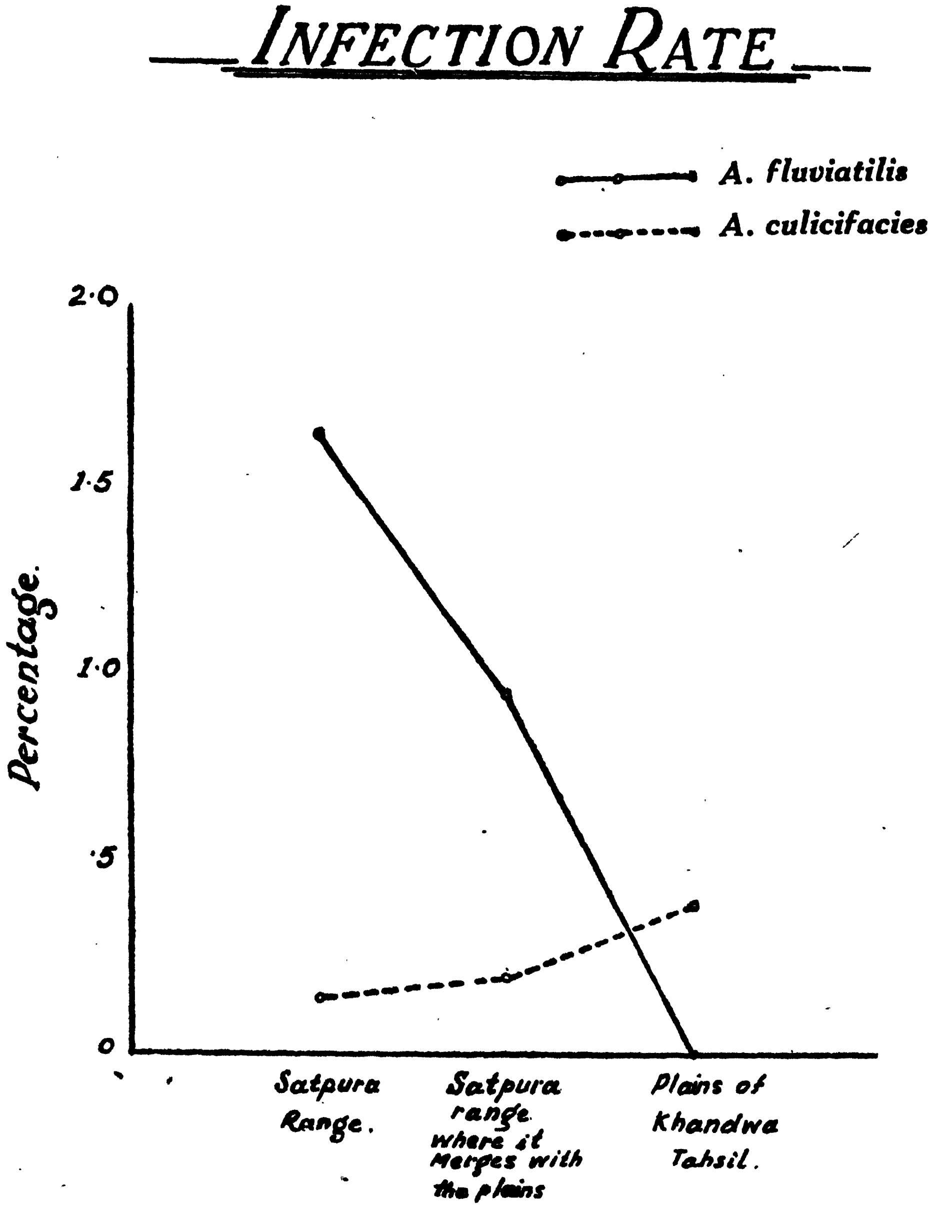
In the hyperendemic areas, both *A. fluviatilis* and *A. culicifacies* showed natural infection, whereas in the plains where malaria is not endemic *A. culicifacies* was the only species encountered with natural infection.

A. fluviatilis, *A. culicifacies* and *A. theobaldi* were associated with high endemic malaria in the jungle villages.

CONCLUSION.

1. The principal vectors in the Western C. P. are *A. fluviatilis* and *A. culicifacies*. *A. culicifacies* plays at most only a very small part in malaria causation in the Western Satpura Range.
2. There is no transmission of malaria in July and August in Western C. P.

GRAPH.


INFECTION RATE
A. fluviatilis
A. culicifacies
2·0
1·5
1·0
·5
0
Percentage.
Satpura Range.
Satpura range where it Merges with the plains
Plains of Khandwa Tahsil.

ACKNOWLEDGMENT.

The authors wish to express their thanks to the Director of Public Health, C. P. and Berar, for permission to publish this paper. They also thank Shri T. K. Rao, Shri D. B. S. P. Patnaik, Shri S. G. Bhoyar, Antimalaria Supervisors, and Shri V. Naidu and Shri R. S. Dubey, Insect Collectors, without whose whole-hearted co-operation and readiness to undertake special investigations this paper could not have been published.

REFERENCES.

GOVERDHAN, G. R. (1912) ... *Report on the malaria investigations from October* 1911 to April 1912. Govt. Press, Nagpur.

KENRICK, W. H. (1911) ... *Report upon malaria in the Central Provinces.* Govt. Press, Nagpur.

SENIOR WHITE, R. (1940) ... Studies on the behaviour of adult *A. culicifacies.* Part III. Dissection records. *J. Mal. Inst. Ind.*, **3**, pp. 363–382.

COMMUNICATIONS

IN July 1947 you favoured me with the hospitality of your correspondence columns to announce certain changes in the dosage of 'Paludrine'. Consequent on these changes in dosage it has become convenient to make available to the medical profession two new sizes of 'Paludrine' tablets. The availability of these new tablets is being announced in the medical press, but I shall be glad of the privilege of using, once again, your correspondence columns to inform the medical profession of the reason for introducing the new-sized tablets.

The matter will be better understood, if I first recapitulate briefly the recommendations with regard to 'Paludrine' dosages :—

(1) For protection against malignant tertian and suppression of benign tertian malaria—0·3 gm. once weekly, or 0·1 gm. twice a week at 3 and 4-day intervals.

(2) For radical cure of malignant tertian malaria—0·3 gm. twice daily for 10 days.

(3) In benign tertian malaria, the greatest hope of a radical cure with 'Paludrine' is offered by the dosage regime of 0·3 gm. daily until the fever subsides, and then 0·3 gm. once a week or 0·1 gm. twice weekly at three and four-day intervals for about 6 months.

(4) For 'clinical' cure of all types of malaria—0·3 gm. daily until the fever subsides.

(5) For children over ten, the dosage for adults is indicated both for treatment and prophylaxis. Children under ten should be dosed according to age and size, but the minimum given to any child, however young, need not be less than 0·025 gm.

It is clear from the dosage schedules enumerated above that the most convenient dosage unit of 'Paludrine' is 0·3 gm. for adults and 0·025 gm. for young children. Tablets containing these quantities of 'Paludrine' hydrochloride have therefore been made available to the medical profession.

Yours faithfully,

J. M. MUNGAVIN, M.B., B.Ch. (Cantab.),
Medical Service Department,
I. C. I. (India) Ltd.,
Calcutta 1.

INDEX OF AUTHORS

INDEX OF SUBJECTS

I.A.R.I. 75

INDIAN AGRICULTURAL RESEARCH
INSTITUTE LIBRARY, NEW DELHI.

Date of Issue	Date of Issue	Date of Issue

GIPNLK—H-40 I.A.R.I.—29-4-55—15,000